Essays in Macroeconomics of Emerging Markets

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ESSAYS IN MACROECONOMICS OF EMERGING MARKETS

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Abstract

by

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My dissertation focuses on the macroeconomics of emerging and developing nations. This group of economies is characterized by significant differences in terms of institutional quality, financial development, as well as other cultural, social, political parameters. In turn, these structural heterogeneities exert considerable influence on their domestic economic environment, specifically impacting key macroeconomic indicators such as output, investment, consumption, foreign capital flows, exchange rates etc. Understanding these nuanced relationships and analyzing them from various dimensions has served as the motivation and the foundation of my doctoral research.

The first essay is an empirical and theoretical investigation of *Business Cycles and Macroeconomic Dynamics in post-independence India*. India's growth performance was touted as ordinary relative to the rest of the world during the first three decades after it gained independence in 1947. However, path-breaking deregulation and liberalization reforms in the 80s and 90s led to substantial growth acceleration and India's metamorphosis into a market-based economic system with strong international ties. This makes the Indian case study really unique and fascinating.

Using annual time series data, we document key business cycle properties of the Indian economy. Output, consumption and investment are more volatile in India com-

pared to its developed country counterparts. As in developed countries, consumption is less volatile and investment is more volatile than output in the Indian data. In contrast, investment is not highly correlated with output in India. Moreover, India's economic landscape has undergone significant changes, both in terms of the absolute level and cyclical fluctuations, across the planning horizon. The presence of structural break is reported for major macroeconomic variables when we decompose the data into pre- and post-reform categories. We also test whether a standard real business cycle (closed economy) model with India-specific parameters can replicate the stylized features of the business cycle. The model includes a tax on capital income which acts as a disincentive for future investment, and the results indicate that a high volatility of the tax shock is required to produce the low investment output correlation. The model performs reasonably well in matching the correlation dynamics observed in the data.

In the second essay, I examine *Foreign Reserve accumulation in Developing Countries through the lens of Institutional Quality and Financial Development.* In recent times, several emerging markets have been providing the rest of the world, and especially the United States, with net resources in the form of current account surpluses. The most noteworthy aspect of the surge in upstream foreign capital flows has been the enormous increase in international reserves held by several emerging economies. Whereas private capital flows are broadly in sync with the standard neoclassical model, capital outflows from relatively high-productivity emerging markets can be explained by the accumulation of official reserve assets.

I investigate the foreign reserve dynamics in developing countries; from both an empirical and theoretical dimension. Using a novel panel dataset combining aspects of openness, institutional quality, and financial development and an innovative clustering method; I present a new approach to identify cross-national structural heterogeneity

and assess its relationship with foreign reserves. I use partition-based cluster analysis to document underlying reserve dynamics and identify systematic variation across and between different country groups. The resulting cluster outputs reflect the presence of cross-national variations in reserve accumulation. Moreover, a series of the scatter plots encapsulating various dimensions of institutional quality and financial development points towards the resounding presence of structural heterogeneity in foreign reserve dynamics in our developing country sample. Cross section and panel data regressions reinforce the initial hypotheses concerning the role of institutional and financial development in international reserve dynamics of the developing world.

I also build a theoretical model embedding the key insights from the empirical analyses in order to propose a coherent framework for explaining the link between institutions, financial development reserve accumulation. The model underscores the importance of financial market efficiency and the institutional environment in explaining reserve dynamics of major developing countries. A series of comparative static exercises shed light on the impact of heterogeneity in institutional parameters and foreign reserve policy on select macroeconomic variables.

In a nutshell, by going beyond the regional differences, we provide a unique vantage point to understand how disparities in institutional and financial conditions influence reserve dynamics in different country clusters. Our results indicate that income, openness, institutional quality and financial development play an instrumental role in explaining the underlying patterns of reserves accumulation in the developing world. However, the effects of these structural indicators are markedly different across clusters of relatively similar countries in terms of their magnitude as well as direction.

Contents

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Chapter 1

Business Cycles and Macroeconomic Dynamics in India

1.1 Introduction

India is one of the fastest growing emerging economies in the world today; with an average quarterly GDP growth of 8.1 percent between 2004–2010.[1] Interestingly enough, India's growth performance was touted as ordinary relative to the rest of the world during the first three decades after it gained independence in 1947. However, path-breaking deregulation and liberalization reforms in the 80s and 90s led to substantial growth acceleration and India's metamorphosis into a market-based economic system with strong international ties. This makes the Indian case study really unique and fascinating, as it depicts an economy that was relatively stagnant, stuck in a low-level growth trap and stifled by enormous growth blockages, but that managed to turn it all around in a strikingly short period of time.

[1] Long time series of seasonally adjusted quarterly data are not produced by the statistical system in India. For business cycle measurement, the NIPFP-DEA program started computing seasonally adjusted quarterly GDP data from 1999.

An understanding of key macroeconomic movements in India is important not only for designing appropriate domestic stabilization policies, but also for the rest of the world to evaluate India's attractiveness as a trading partner and foreign investment destination. This motivates a systematic inquiry of India's business cycle.[2]

The Real Business Cycle (RBC) model is regarded as the workhorse framework in dynamic macroeconomic research. While RBC models are successfully applied to developed economies, their ability to replicate the salient features of developing countries is still being explored. In this paper, we make a two-fold contribution. On the empirical side, we use annual data and two types of filtering techniques to document business cycle statistics for the Indian economy.

Our main empirical findings are that output, consumption and investment in India are more volatile than in developed economies. As in developed countries, consumption is less volatile and investment more volatile than output in the Indian data. In contrast, investment is not highly correlated with output. Even if we consider data from the more recent decades following economic liberalization, the correlation between investment and output in India is much lower than in the US.

As a supplementary quantitative exercise, we conduct a time series exploration of the Indian economy through the twin lenses of central planning (five year plans) and economic liberalization initiated in 1991. A structural break is evident for major macroeconomic variables such as output, consumption, and investment. In addition, these variables display considerably higher rates of growth and more pronounced volatility in the post-reform period. The level and growth differentials underscore the critical impact of economic liberalization and deregulation policies on India's economic performance.

[2]With a labor force of about half a billion, labor market and employment fluctuations are also an important facet of India's business cycle. However due to lack of consistent labor market statistics especially organized employment, hours worked etc., we exclude labor from the current analysis. Section 1.6 presents a comparison of our benchmark model with its elastic-labor counterpart.

On the theoretical front, we test whether a standard RBC model (closed economy framework) driven by a transitory technology shock, a shock to capital income tax, and parameters calibrated for the Indian economy can replicate the stylized features of the data. In the model, we assume that the government levies a tax on capital income to finance its expenditures. With only productivity shocks driving fluctuations, the model cannot capture the low correlation between investment and output movements. When there is a positive tax shock (in addition to the standard productivity shock) and especially if it is likely that there is a high tax rate in subsequent periods, capital becomes more expensive as the return to capital is reduced and there is less incentive to invest in future capital. Therefore on impact investment does not respond strongly to movements in output, leading to a low correlation. Our results suggest that a high volatility of the tax shock is required to match the low investment-output correlation.

A serious weakness of the closed economy framework is its inability to fully capture India's macroeconomic landscape in the last two decades. Far-reaching economic reforms initiated in 1991 have led to India's gradual transition towards a small open economy. This warrants the study of India's business cycles through the lens of an open economy model in order to understand the growing importance and contribution of foreign capital and net exports in the recent times. We take a step in this direction by extending our benchmark closed economy framework to a small open economy model (along the lines of Schmitt-Grohe and Uribe (2003) and present some key results indicative of overall model performance.

Due to the lack of consistent and comparable time series data on labor force and employment, we abstract from labor movements in the model. To put our results in perspective, we calibrate the RBC model with labor and without labor movements for the US, and comment on the bias that results from excluding labor in the analysis of our benchmark model for India. We find that fixing labor supply at unity leads to

attenuation of model moments in comparison to the empirical moments.

The focus on business cycle models for emerging economies is relatively recent. In a seminal paper, Aguiar and Gopinath (2007) find that if the technology shock is appropriately modeled to include transitory and trend components, a standard RBC model can explain the high volatility of developing country business cycles. Neumeyer and Perri (2005) evaluate the role played by interest rates in the business cycles of emerging economies and contrast it with the role played by productivity shocks.

Some authors argue that a standard RBC model might not be the most relevant theoretical benchmark to study and replicate key business cycle properties of all developing countries. Bergoeing and Soto (2005) incorporate characteristics of the Chilean economy in the RBC framework and find that in addition to technology shocks, fiscal policies and labor market rigidities constitute the main sources of the business cycle fluctuations.

An integral part of business cycle analysis in India relates to developing leading and coincident indicators to facilitate forecasting of booms and recessions as well as dating cycles. Chitre, in a series of studies, presents evidence of synchronous movements in non-agricultural output, industrial production, capital formation and other monetary variables. He identifies indicators of growth cycles and characterizes the Indian economy as experiencing five growth cycles of economic activity during the period 1951–1975. Dua and Banerji (1999) adopt the NBER business cycle dating approach and identify six business cycle recessions from 1964–1997, averaging less than a year. Though there is a history of business cycle research pertaining to India, it is mainly confined to descriptive investigations.

This paper is most closely related to recent empirical work by Ghate, Pande and Patnaik (2013), wherein they document stylized facts of India's business cycles by investigating the volatility and correlation dynamics of key macroeconomic variables

when the data is divided into pre- and post-reform samples. Nevertheless, our paper is significantly different in several aspects.

Our empirical inquiry is based on two critical vantage points namely; the series of five-year plans (beginning in 1950) as well as the onset of economic reforms in 1991, whereas the work by Ghate et al. focuses specifically on the latter. Moreover, before presenting a systematic empirical analysis of our key economic variables, we determine whether Indian economy indeed experienced a structural break sparked by the economic reforms of 1991. In other words, we test if two distinct trends are present in the pre- versus post-reform sample. We also compare our key results (volatility and correlation) against the relevant US data, as a developed country benchmark, to identify similarities and differences. Most importantly, our paper makes a dual contribution. We not only present an empirical snapshot of India's post-independence macroeconomic environment but also attempt to study if standard theoretical models of real business cycles, including both closed and small open economy frameworks, can explain the key empirical regularities pertaining to the Indian economy.

The rest of the paper is organized as follows. In Section 1.2, we discuss the data and compute the business cycle statistics for the Indian economy. Section 1.3 sheds light on two empirical experiments performed using the data and outlines the main observations. Section 1.4 presents the basic RBC model, describes the parameters used for calibration and discusses estimation of the parameters of the technology process. In Section 1.5, we report main results from our models. Section 1.6 analyzes a model with elastic labor supply to provide a point of comparison with our benchmark theoretical framework (assuming inelastic labor supply). Section 1.7 provides concluding remarks.

1.2 Business Cycle Statistics for India

1.2.1 Methodology

A serious constraint for business cycle research in India, both empirical and theoretical, is the unavailability of long time-series data at monthly or quarterly frequency for major macroeconomic variables. We compute the relevant statistics using the longest annual time-series data. The data on output, consumption (both private and government) as well as investment (gross capital formation) are extracted from the Reserve Bank of India for the period 1950–2012.[3]

We transform the data into log format and employ the technique of Hodrick – Prescott (HP) filtering to remove the long-run trend and isolate the cyclical component of the time series. Given the annual frequency of the data, the value for the smoothing parameter λ has to be adjusted appropriately. We follow Ravn and Uhlig (2002) and set $\lambda = 6.25$.[4] While the value of $\lambda = 1600$ has been shown to be a good approximation for quarterly data, for annual data, there is less agreement in the literature.[5] Hence we also present results using the Band-Pass Filter (BP) based on the algorithm proposed by Baxter-King (1999). In particular, we employ the specification $BP - K(p, q)$ where $K = 3$ (lag length for the moving average), $p = 2$ (shortest cycle length) and $q = 8$ (longest cycle length) with reference to annual data.[6] The two filters provide very similar results for the statistics computed.[7]

[3]In the closed economy, GDP is the sum of private consumption and private investment. In case of the open economy, GDP is composed of private consumption, government consumption, investment and net exports. See appendix I for the precise accounting definitions used.

[4]Ravn and Uhlig (2001) provide empirical evidence for the US indicating that the smoothing parameter should be adjusted using the fourth power of frequency change when moving from quarterly to annual data. The standard value for λ used at quarterly frequency is 1600, so this adjustment yields a value of 6.25 for annual data.

[5]Backus and Kehoe (1992) use $\lambda = 100$, while Correia, Neves and Rebelo (1992) and Cooley and Ohanian (1991) suggest a value of 400 for annual data.

[6]Dua and Banerji (2001) find that the average length of the business cycle is six years.

[7]Baxter and King (1999) show that a value of λ close to 10 results in a strong correspondence between the Hodrick –Prescott and the Bandpass filters.

1.2.2 Findings

Figure 1.1 shows the cyclical evolution of output, consumption and investment in India between 1950 and 2012. We observe that several cycles exist with distinct magnitude and length. Consumption moves closely with output as in developed countries. As a fraction of GDP, private consumption decreased from around 85 percent in the beginning of the sample to 60 percent at the end. The share of private investment increased from 8 percent to 25 per cent from 1951 to 2012. This expansion in investment share is accompanied by greater volatility.

Table 1.1 provides a summary of the business cycle statistics for the Indian economy. We report three key statistics namely; amplitude of fluctuations or volatility (percent standard deviation of the cyclical component of each series), volatility relative to that of output (the ratio of standard deviation of the given series to that of output) and co-movement (the contemporaneous correlation of the cyclical component of a series with that of output).

We can identify some prominent features of India's business cycle based on Table 1.1. In general, consumption (aggregate and private) is less volatile compared to output. On the contrary, government spending and investment are significantly more volatile vis-a-vis total output. In particular, private investment is 5.5 times as volatile as output and displays a particularly weak correlation with output with a coefficient of 0.24. The majority of the variables seem to have experienced a volatility moderation in the aftermath of the economic liberalization as reflected in the post-reform volatility measures. Interestingly enough, while investment volatility is more or less constant throughout the entire time span, investment-output correlation has markedly improved in the post-reform era. Also, consumption and investment display a higher relative volatility (compared to output) in the post-reform period, thus underscoring the fact that output volatility in India has fallen more than proportionately

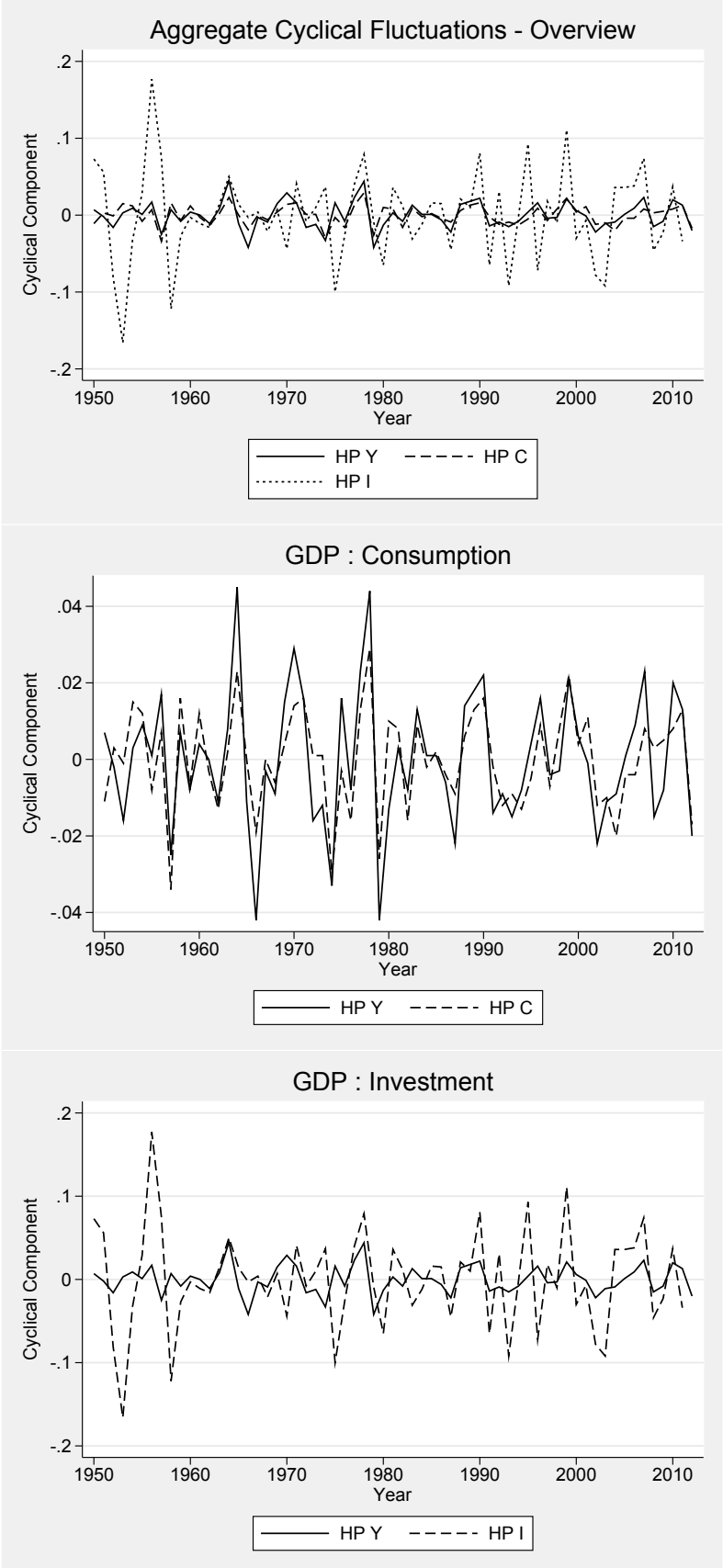

Figure 1.1: Cyclical Output, Consumption and Investment

	1950–2012	1950–1991	1992–2012
Volatility			
GDP	1.74	1.92	1.36
C	1.29	1.37	1.13
I	5.89	5.95	5.91
PC	1.36	1.50	1.06
PI	9.54	10.28	8.02
GC	2.92	3.11	2.55
Relative Volatility			
GDP	1.00	1.00	1.00
C	0.74	0.72	0.83
I	3.38	3.10	4.35
PC	0.78	0.78	0.78
PI	5.47	5.35	5.91
GC	1.67	1.62	1.88
Correlation			
GDP	1.00	1.00	1.00
C	0.79	0.81	0.74
I	0.29	0.22	0.55
PC	0.80	0.80	0.79
PI	0.24	0.17	0.51
GC	0.18	0.14	0.30

Table 1.1: Business Cycle Statistics: Pre- and Post-Reform India

Note: The first column refers to the full sample period, the second denotes the pre-reform period and the last column is for the post-reform period. C and I measure aggregate consumption and gross capital formation respectively. PC and PI refer to private consumption and private investment (household + corporate) whereas GC measures government consumption expenditure.

compared to its components in the last two decades.

A relevant exercise at this stage would be to compare India's business cycle statistics to the corresponding values for the US cycle. We calculate the same statistics using annual data for the US for the similar time period (1950–2012). The data are extracted from the US National Income and Product Accounts. We use seasonally adjusted annual time series for personal consumption expenditure and gross private domestic investment. GDP is the sum of private consumption and private investment in our benchmark closed economy. On the other hand, when we consider the small open economy framework, our definition of GDP is extended to include aggregate consumption (private consumption + government consumption), aggregate investment

(proxies by gross capital formation) and net exports.[8]

We compute the statistics using the HP filter.[9] All variables in India display higher volatility compared to the US.[10] As in the US, private consumption in India is less volatile than output.[11] Aguiar and Gopinath (2007) find that in emerging markets, consumption is generally more volatile than output. Only two of the thirteen countries studied by them show a ratio of consumption to output volatility of less than one. Private consumption in India is procyclical as in the US with a correlation coefficient of 0.8. The most striking difference between the stylized facts in India and the US is that the correlation of (gross private) investment with GDP is 0.87 in the US, while in India it is a meager 0.24. This significantly low investment-output correlation is investigated further.

1.2.3 Investment dynamics

As the Indian economy underwent deregulation and liberalization reforms during the latter half of our sample period; it is instructive to analyze investment data through distinct time windows and in different sectors. Total investment (Gross Capital Formation) as a share of GDP jumped from 10 percent in the beginning of the sample to 36 percent towards the end.[12]

Decomposing the total investment into that of the household sector, private cor-

[8]Table 1.11 in appendix I compares key business cycle statistics in India vis-a-vis the US.

[9]Cooley-Hansen (1981) document the main business cycle statistics in the US using quarterly data for the time period 1955–1984. Some of the key values reported are as follows: output volatility (1.74), consumption volatility (0.81), investment volatility (8.45), correlation of consumption with output (0.65) and correlation of investment with output (0.91).

[10]Others have documented this fact for developing countries. Aguiar and Gopinath (2007) find that on average emerging market economies have a business cycle twice as volatile as their developed counterparts.

[11]This feature is helpful because in the RBC framework, consumption is modeled under the permanent income hypothesis. Hence consumption volatility should be smaller than output as agents try to smooth consumption intertemporally.

[12]The data for sectoral investment is obtained from the Handbook of Statistics on Indian Economy published by the Reserve Bank of India.

porate sector, and the public sector shows that prior to the reforms, the bulk of investment took place in the public sector (around 45 percent). The share of household investment in total investment has been steady across the years, ranging between 35-40 percent. In contrast, the share of corporate investment in total investment, which was roughly 16 percent till 1991, almost doubled to 31 percent after 1991.

A look at the relative volatility of investment (vis a vis output) shows that government investment has remained relatively stable. Investment was mainly undertaken by the public sector based on five year plans and not by forward-looking private firms. However, after the economic reforms, entry barriers were eliminated and firms gained flexibility in making investment decisions. As Shah (2008) points out, in an environment of greater competition from domestic and foreign firms where profit expectations drive investment decisions, as well as exposure to financial markets, the investment by private firms was highly variable.

We take a closer look at the main components of India's gross investment by examining them across different time periods (presented in Table 1.2). Corporate investment in India displays significantly higher volatility (both absolute as well as relative) compared to the US. Specifically, the volatility of private corporate investment relative to output was around 10.6 post-1991. Furthermore, while the correlation of corporate investment to output was very weak (mildly negative) in the early years, it increased to over 0.4 in the late 70s and 0.6 during the 90s. Nevertheless, comparing this to the US shows that the correlation of corporate investment with output is still much smaller over the cycle in India.

Non-residential investment in the US moves very closely with output and the correlation has been increasing over the decades; in the period 1992–2012, the correlation was 0.91. In addition, the correlation of US private and gross domestic investment with output since the 1970s has been close to 0.95 and 0.96 respectively. In contrast,

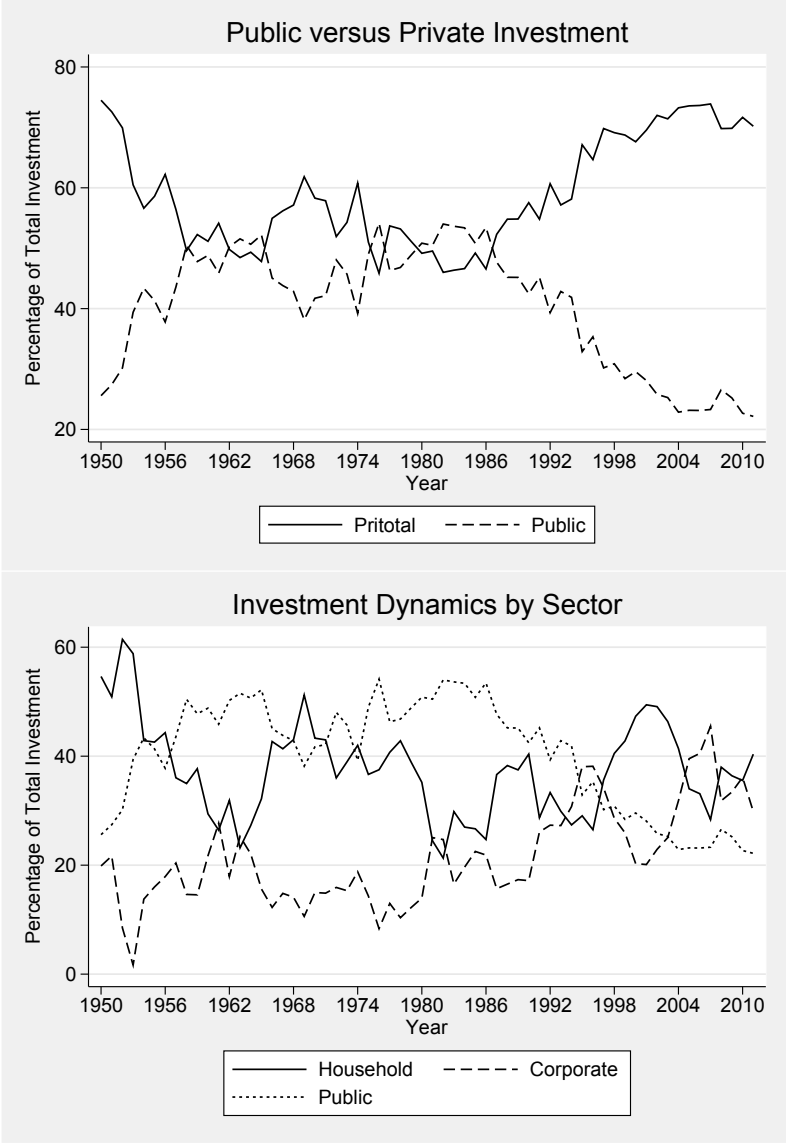

Figure 1.2: Snapshot of India's Investment Dynamics

Share	HH	Corp	Pub	Total I
1970–1991	7.03	3.53	9.76	20.31
1992–2011	10.73	9.27	8.09	28.59
1970–2011	8.79	6.26	8.96	24.40
1950–1991	6.21	2.95	7.92	17.07
1950–2011	7.67	4.99	7.98	20.89
Relative Volatility	**HH**	**Corp**	**Pub**	**Total I**
1970–1991	4.51	7.63	1.99	2.05
1992–2011	5.81	10.61	3.38	4.32
1970–2011	4.81	8.22	2.36	2.69
1950–1991	4.21	13.05	2.12	2.57
1950–2011	4.41	12.78	2.29	3.61
Correlation	**HH**	**Corp**	**Pub**	**Total I**
1970–1991	0.27	0.42	0.08	0.53
1992–2011	0.03	0.61	0.50	0.63
1970–2011	0.21	0.47	0.21	0.53
1950–1991	0.21	-0.07	0.09	0.23
1950–2011	0.19	-0.01	0.01	0.29

Table 1.2: Sectoral Investment Dynamics: India

Note: The four columns represent household, private corporate, public and total investment (gross capital formation) respectively. The first panel reports sectoral investments as a share of GDP (percentage), the second panel depicts the volatility of each investment component relative to output, and the last panel presents period averages of the investment-output correlation. We HP filter the data and use the cyclical series to compute volatilities and correlations.

the maximum private investment-output correlation for the Indian economy is still about 0.6 and observed strictly in the post-reform period. Investment dynamics for the US economy are presented in Table 1.12 included in appendix I.

1.3 Two Empirical Experiments

> "If August 15, 1947 marked the Indian Independence- from political slavery to colonial power, then I think the August of 1991 could be marked as the beginning of Indian Economic Freedom". Dr. Narendra Jadhav[13]

Two unique features of the Indian economy warrant a systematic empirical inves-

[13]Dr. Narendra Jadhav currently serves as a member of the Planning Commission of India.

tigation. First, the use of five year plans as a principal policymaking tool by the Indian government and second, the defining year 1991, which marked the initiation of far-reaching economic liberalization in India. We are using the longest available time series for most of the macroeconomic aggregates, which facilitates a time series exploration of the economic dynamics in India from these two distinct vantage points. We start with a brief background to set the stage and motivate our empirical analysis, which is presented in the following sections.

1.3.1 The History of Five Year Plans in India

India is a force to be reckon with in today's global economic landscape. The transition was by no means easy. A series of five year plans laid the policy foundation and provided a guiding map for operating the economy. Since 1951, the year when the first five year plan was presented by then Prime Minister Jawaharlal Nehru, India has indeed attained several economic milestones. It has taken giant strides and is considered one of the emerging superpowers today.

During the first three decades since independence (1950–1980), India firmly adhered to the economic strategy of planned growth. This inevitably led to entrepreneurial abilities of people being closely intertwined with the web of myriad controls, government regulations and licenses — so much so that the Indian economy was nicknamed the "License Raj".

India's post-independence economic landscape is primarily based on the concept of planning, executed through a series of centralized national economic programs, the Five Year Plans (FYP).[14] India is one of the few countries which have still retained the tradition of using five year plans as a primary regulatory and policymaking

[14]The Soviet Union spearheaded the planning revolution in the 1920s, being the first nation to implement five year plans under Joseph Stalin's leadership. This policymaking platform has been subsequently adopted by the majority of communist economies as well as several capitalist nations.

mechanism. However, the extent of government involvement and intervention in the planning process has undergone a marked transition, beginning with a tightly regulated planning philosophy but eventually giving way to a more hands-off approach to governance termed as 'Indicative Planning'. Today, the primary focus is to establish a long-term strategic road map and identify key economic priorities and corresponding sectoral targets for India.

Economic development has been the underlying theme for each of the twelve five year plans implemented thus far. However the relative sectoral emphasis has shifted markedly over time. Agriculture and allied activities were the focal point in the initial stages of the planning period followed by infrastructure and defense. Over time, advancement in industrial production and productivity improvement gained prominence. Economic liberalization and deregulation is the central theme since the sixth plan (1980 onwards), and has further intensified in the post reform era (1992 onwards).

1.3.2 The Advent of Economic Reforms

India was predominantly insulated from international trade for more than four decades post-independence. The adoption of an inward-oriented development strategy coupled with strong resistance towards foreign trade and investment inevitably led to India's marginalization in world trade. Moreover, despite the dramatic rise in private capital flows directed towards developing countries since the mid-eighties, India was not regarded as a particularly attractive foreign investment destination.

A severe balance of payments crisis surfaced in the Indian economy in 1991, exacerbated by a precarious foreign exchange reserve position. The ensuing period of economic and political upheaval marked the beginning of significant structural transformation of the Indian economy. Far-reaching economic reforms targeting widespread

industry deregulation, privatization and economic liberalization were spearheaded by then Finance Minister Dr. Manmohan Singh. The subsequent transition of India from a heavily regulated economy to a dynamic market economy has indeed been remarkable. Therefore it would not be appropriate to view the economy pre- and post-1991 from the same vantage point.

India was indeed a late entrant in the reforms arena, embarking on the journey with full steam only in 1991.[15] However the strong need of a paradigm shift was felt much earlier, as many of India's counterparts in East Asia achieved the twin goals of sustained high growth and drastic poverty reduction through outward-oriented export promotion policies and strengthening the private sector. The Indian government did introduce some key policy initiatives targeting widespread industrial development and privatization in the 1980s. But it was not until 1991 that a systemic transition to a more open economy with greater market reliance, a dominant private sector, and economy-wide institutional restructuring was truly underway. In particular, reforms of the 1990s were regarded as 'pro-market' in orientation as against the largely 'pro-business' reforms of the 1980s (Kohli, 2005 and Rodrik et al, 2005).

A hallmark of India's reform agenda, in comparison to its East Asian and other developing world counterparts, is the emphasis on evolutionary transition rather than rapid restructuring akin to 'shock therapy'. Gradualism was the natural byproduct of India's parliamentary democracy and a pluralistic political environment where economic reforms can be successfully implemented only if a sufficiently broad consensus can be formed. The favorable economic experience in the 1980s created an intellectual climate for following the same road map, with the 1991 crisis solidifying the need for even more aggressive reforms. This being said, the pace of reforms had to be attuned to India's democratic polity.

[15]This economic scenario is succinctly described by Montek Singh Ahluwalia, Deputy Chairman of Planning Commission of India in his article 'Economic Reforms in India since 1991: Has Gradualism Worked?', Journal of Economic Perspectives, summer 2002.

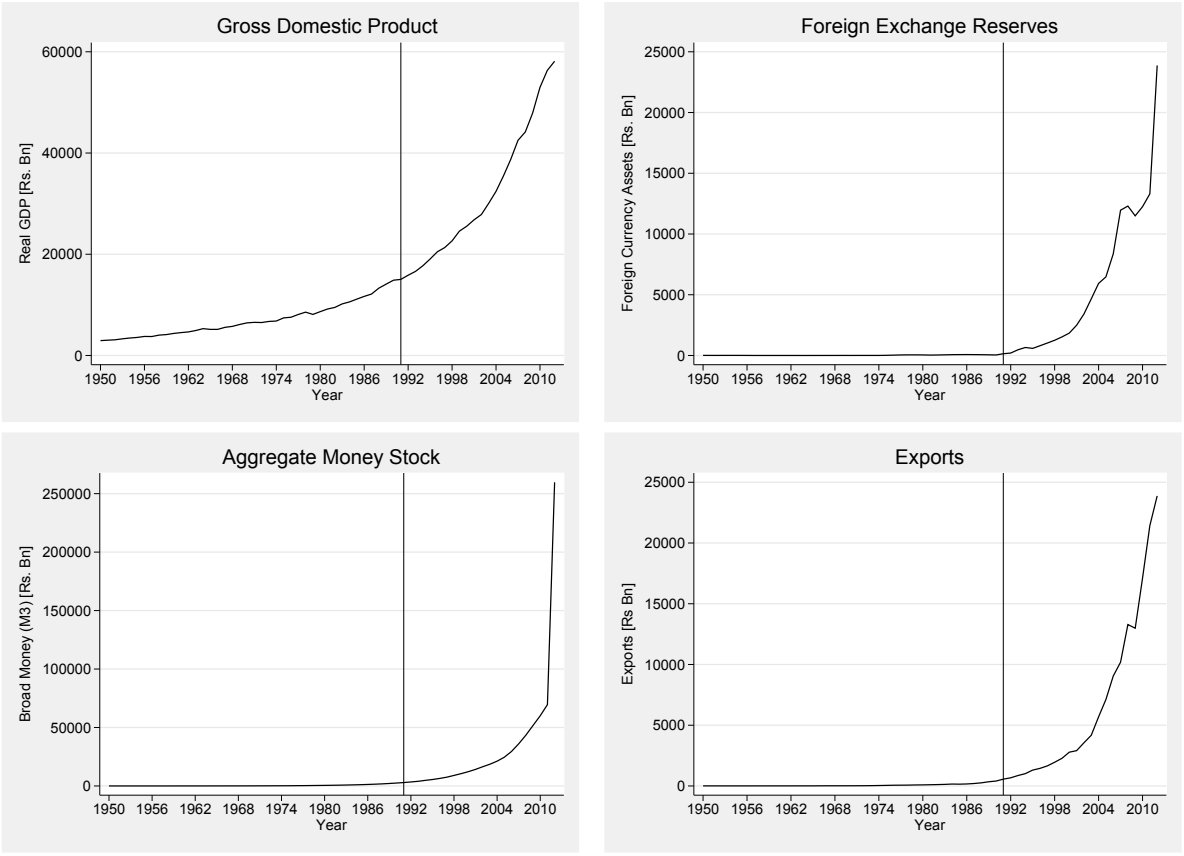

Figure 1.3: India Shining

Note: The vertical bar in all four panels corresponds to year 1991, when India's economic reforms kick started.

Two critical dimensions of India's economic reform stand out namely; macroeconomic stabilization and structural adjustment. Furthermore, structural adjustment consists of Liberalization, Privatization, and Globalization: LPG, a hallmark phrase often used with reference to India's economic reforms.

Has India changed post-reform? Saying 'significantly' would be a mild response. Since 1991, India's GDP has quadrupled, its foreign exchange reserves have skyrocketed from 5.8 billion to 279 billion dollars, and exports have jumped from 18 billion to 178 billion dollars (See Figure 1.3). Most now view India as a global service hub specializing in business process outsourcing, data base production, financial accounting, medical transcription, etc. However, there is a wide spectrum of services and industries wherein India is making major breakthroughs.

In a nutshell, whereas the pre-reform India resembles a heavily planned (closed) economy with government dominance, the post-reform India shares many features of a free market (open) economy. A vibrant service sector, steadily rising foreign capital flows (particularly foreign direct investment) and sustained foreign reserve accumulation are some of the hallmarks of the Indian economy in recent decades.

The long annual time series data for the Indian economy (1950 onwards) can be recast into a series of systematically designed and implemented five year plans. This provides an ideal setting to study the evolution of key macroeconomic aggregates over the entire planning period and identify the underlying trends and patterns.

Our sample covers a total of eleven five year plans. Plans one through seven were administered prior to the reforms and plans eight through eleven were implemented after the reforms.[16] This establishes a direct correspondence between the two empirical strategies used in our analyses.

1.3.3 Empirical Analyses of Planning and Economic Reforms

Before delving into the business cycle properties of Indian economy in the post liberalization era, it seems necessary to conduct a simple thought experiment. We divide the entire dataset into the pre-reform (1950–1991) and post reform (1992–2012) periods. The question is if the Indian economy was different in these two periods. And if so, how significant was the transformation? In other words, we need to understand whether the magnitudes (means) and volatilities (standard deviations) of key macroeconomic variables such as output, consumption (both private and public), investment, etc. were strikingly different before and after economic liberalization.

Table 1.3 below clearly answers our first question with a resounding yes. Even the

[16]The twelfth five year plan is currently underway. Note that three years in our sample period (1967, 1968 and 1991) are excluded from the planning coverage since extraordinary circumstance compelled the Indian government to special annual plans.

crudest indicator, period averages, reflects critical differences in the Indian economy before and after the economic reforms. All the major macroeconomic aggregates have risen dramatically in the last two decades. Despite a cautious growth outlook, high inflation rate and a few setbacks in the wake of the current global financial crisis, many economic variables seem to be maintaining their positive trajectories. This constitutes initial supporting evidence for the occurrence of structural transformation in India.[17]

Time Period	Y	C	I	PC	GC	NX
Pre-Reform	7138.36	6034.21	1399.49	5308.17	726.03	-102.01
Post-Reform	30895.37	22274.70	9138.59	18735.76	3538.94	-1326.17

Table 1.3: India's Economic Transition

Note: Values represent average levels of select economic aggregates for the pre-reform (1950–1991) and post-reform (1992–2012) periods. All variables are real and expressed in billions of rupees (base year 2004-05).

Next we take a closer look at the two sub-samples to determine whether these differences stem from two distinct underlying growth trends.

All the major macroeconomic time series included in our empirical analyses (e.g. GDP, Consumption, Investment and Net Exports) report the presence of a trend break.[18] In other words, there seem to be two distinct trends: one prior to the reforms (pre-1991) and the other after the initiation of reforms (post-1991).

The combined impact of reform and year (captured by the interaction term in the individual regression models) is indicative of a structural break in the post-reform Indian economy. This effect is significant for most of the variables of interest such

[17]Behavior of investment and net exports is markedly different in the pre and post-reform period.This is indicative of significant shifts in the relationship between savings and investment in India.

[18]A strong presence of heteroskedasticity is observed across the board when we divide the data according to five year plans (finer disaggregation) or a single reform dummy (generic disaggregation). We employ the ROBVAR routine in Stata to detect and test group-wise heteroskedasticity. Table 1.13 in appendix I summarizes the distribution of residual volatilities for key macro variables.

as gross domestic product (GDP), aggregate consumption (C) private final consumption (PC), government consumption (GC), two alternative measures of investment namely; gross capital formation (I) and gross domestic capital formation (I2) and finally measures of private investment (PI) and private output (PY). In particular, GDP is significantly more volatile post-reform (with a big jump from plan 6 to plan 7 in particular). Specifically, aggregate output is almost three times as volatile in the post-reform period (when we condense the individual five year plan (FYPLAN) dummies into a single binary REFORM variable). Aggregate consumption volatility increased more than threefold from the pre-reform to the post-reform period. When inspected by individual planning period, a dramatic increase in consumption volatility occurred between plan 7 and 8 (containing the year 1991, when reforms kick in).

In order to understand whether the aggregate consumption dynamics are driven by the private or public sector, we decompose total consumption into private and government consumption respectively. Private consumption mimics the behavior of aggregate consumption and actually magnifies the trend-break and volatility effect. The relative volatility of private consumption post reform is at least 3.5 times that of its pre-reform threshold. Actual values corresponding to plan 7 and 8 reiterate this point. Government consumption also is considerably more volatile in the post-reform era but the absolute magnitudes of volatilities are somewhat tepid compared to their private counterparts.

Post-reform investment volatility (measured by Gross Capital Formation) is more than eight times its pre-reform level. This is indicative of pronounced fluctuations in investment as a by-product of economic liberalization. The strongest evidence of trend break and correspondingly the most acute volatility differential is reflected in the net exports series. Net exports volatility post reform is almost 10 times that of its pre-reform level. However, there is an important caveat here. One should note

that since India resembled a heavily regulated economy prior to 1991, the magnitude and fluctuations in net exports are naturally more pronounced (dramatic) post-1991. Thus the post-reform period seems the most relevant for further empirical and policy directive.[19] A number of external sector reforms have been implemented since 1991, such as currency devaluation, abolition of import licensing, a drastic reduction in tariff rates, the gradual removal of quantitative restrictions on imports, and foreign investment liberalization. These policies have been instrumental in shaping India's international trade and investment landscape in the recent times.

In addition to the level variables, we also calculate several key ratios using our data (e.g.consumption to output, investment to output etc.) Government consumption to GDP and investment to GDP ratios depict existence of trend breaks (actual ratio coefficients are relatively small in magnitude compared to the respective levels). Investment to output ratio is twice as volatile post-reform, thus confirming existence of absolute as well as relative volatility.

Annual Growth rates for key macroeconomic variables provide another line of support to our story of structural transformation. Table 1.14 in appendix I depicts the evolution of GDP and consumption growth rates, reinforcing the fact that the trend growth exhibits a general upswing. In particular, average GDP growth was 4.1 percent and 6.8 percent in the pre- and post-reform period, respectively. Moreover, output growth has accelerated steadily throughout the planning period, recording a 3.9 percent average in the first five year plan and almost doubling to 7.67 percent in the tenth plan. Total consumption growth has similarly galloped from 3.8 percent to 6.05 percent between the pre- and post-reform periods.

Table 1.4 below provides another dimension of the growth rate differential. We

[19] After the demise of the Bretton Woods system of fixed exchange rates in 1971, India's exchange rate policies led to significant depreciation of the rupee. Supplemented by active export promotion, this favorable exchange rate environment paved way for Indian export growth to gain some momentum in the early 80s, with further acceleration witnessed after the economic reforms.

divide the entire dataset into decades to supplement our original pre-post reform classification. Next we compute cumulative annual growth rates for each of the sub-periods. Inspection of the entries in each column is indicative of a general upward growth trajectory through the decades. Moreover, when we focus on the last two rows of the table, covering the pre- and post-reform periods, the evidence is even stronger. The growth gap for net exports is the most striking, due to dramatic increase in trade deficit after liberalization led- trade openness. This acceleration in the volume of trade deficit is depicted in Figure 1.4 below.

Time Period	Y	C	PC	GC	I	NX
1950–1959	3.86	3.64	3.66	3.34	4.39	
1960–1969	3.85	3.41	2.88	9.16	5.59	
1970–1979	2.60	2.91	2.70	4.47	5.03	
1980–1989	5.56	4.61	4.20	7.17	6.74	
1990–1999	5.73	5.06	4.80	6.39	7.08	
2000–2012	7.39	6.66	6.76	6.17	11.33	
1950–1991	4.06	3.78	3.55	5.82	4.96	1.30
1992–2012	6.86	6.18	6.12	6.43	9.40	17.46

Table 1.4: Macroeconomic Snapshot of India: Compound Annual Growth Rates
Note: The last two rows present pre-reform and post-reform values respectively. Analysis of India's Net Exports seems to be more relevant and meaningful in the post-reform period based on their magnitude and volatility. Therefore, we have chosen not to report decade-wise growth numbers.

To shed light on the post-reform evolution of net exports, we created another classification scheme for our sample using the variable 'reformnew'.[20] The bottom panel in Figure 1.4 presents net export dynamics for the specific time periods as defined by this new variable. We can clearly see successive deterioration in India's trade balance from point one through four (corresponding to the post-reform five year plans).

How the key components of India's gross domestic product have evolved in the post-

[20]Keeping in mind the correspondence between five year plans and the reform break, the variable 'reformnew' integrates our two empirical approaches. All the five year plans prior to reforms (one through seven) are treated as the reference category 0 and each of the post-reform five year plans are treated separately.

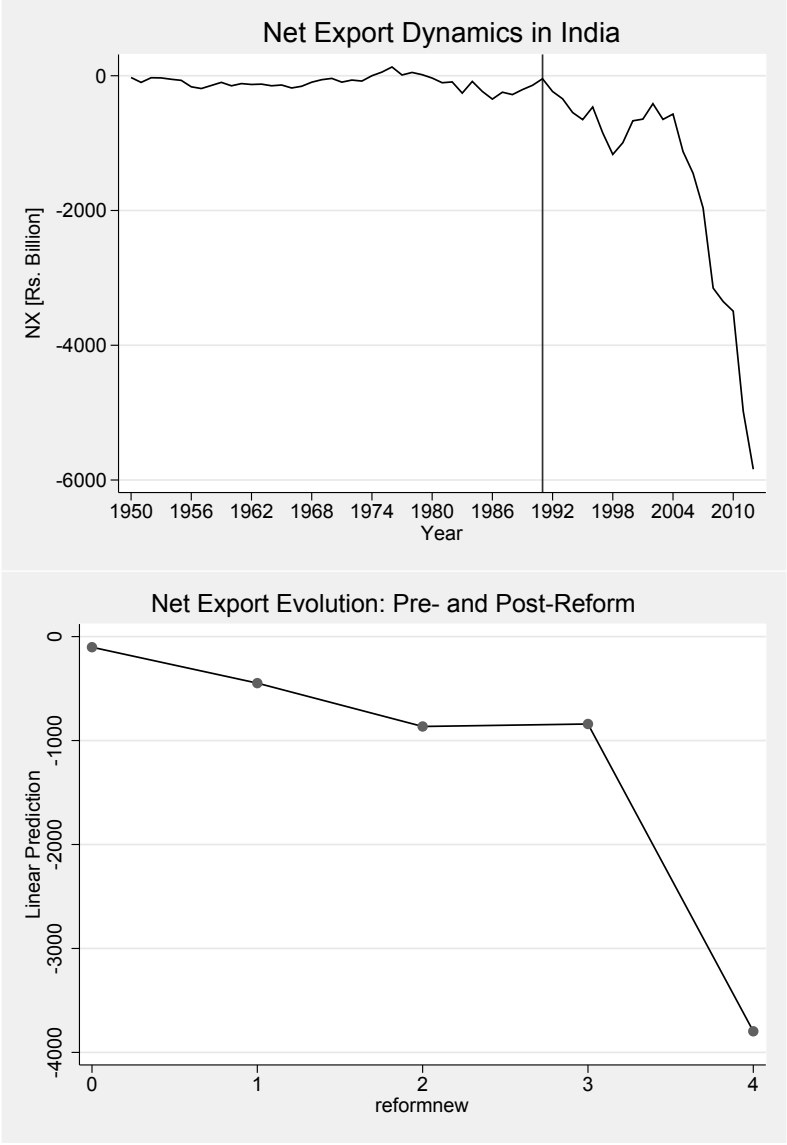

Figure 1.4: India's Net Exports

independence era is another interesting question to analyze. A noteworthy feature of the Indian economy is the secular decline in the share of consumption to output, accompanied by a sustained rise in the investment share as depicted in the top panel of Figure 1.5 below. This underlines the changing importance of private consumption and investment as twin engines of economic growth in the recent times. In particular, the share of investment seems to have picked up from the seventh plan onwards, triggered by the abolition of License Raj initiation of industrial deregulation and the initial wave of privatization. The share of government consumption appears to be remarkably stable and relatively small over the last six decades, indicating a relatively small role of the public sector [see the bottom panel of Figure 1.5].

Net exports in India warrant a special treatment since their magnitude and relevance is limited to the post-reform period of trade openness. It is clear from the bottom panel in Figure 1.4 below that despite the burgeoning trade deficit since the mid-90s; net exports continue to be a very small component of India's GDP.

Next we consider the two broad categories comprising aggregate investment namely; private (household + corporate) and public investment and inspect their respective shares in total output across the entire sample period. As reflected in Figure 1.6 below, the private investment to output ratio in India is on a steady upward path since the mid-80s. This is mirrored in the steady decline in public investment share during the same time. Lastly, we focus on the narrow measure of output, which is the sum of private consumption and private investment. The share of private consumption in private output has experienced a secular fall coupled with a concomitant six-fold rise in the share of private investment. This reinforces the argument that the Indian economy is indeed undergoing a structural transformation. In other words, consumption dominance in India is being challenged by the emergence of private investment as a strong growth driver in the post-reform era.

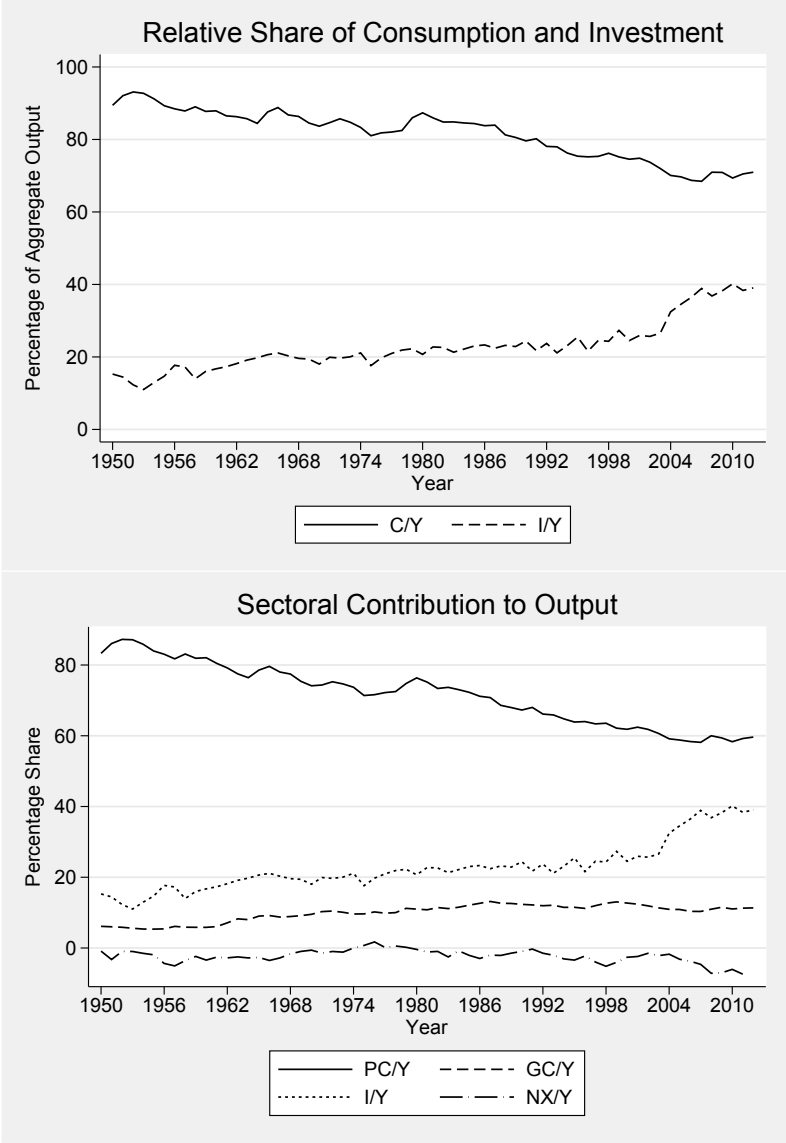

Figure 1.5: Overview of Sectoral Dynamics

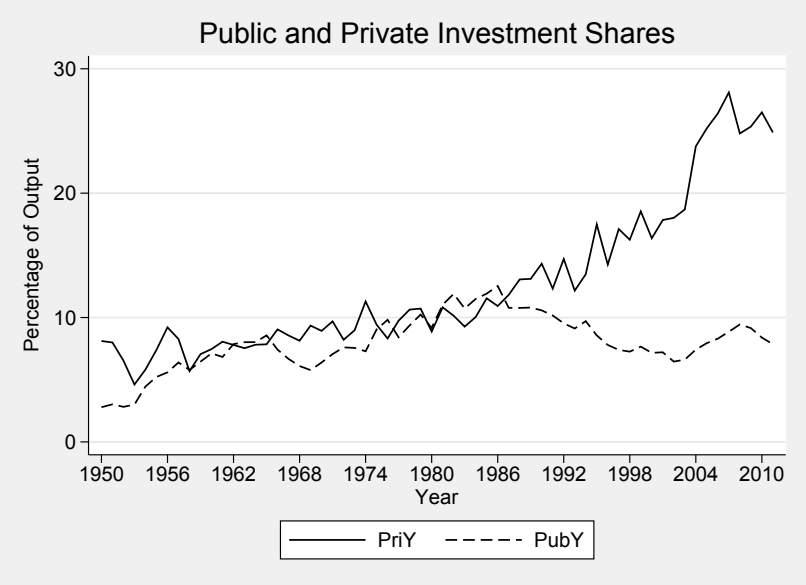

Figure 1.6: Public vs Private Investment

1.4 Model

1.4.1 Closed Economy Framework- Theoretical Benchmark

In this section we present the standard real business cycle model that incorporates a productivity shock and as fiscal shock. The economy consists of a representative household that has preferences over the sequence of consumption C_t described by

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma} \tag{1.4.1}$$

where $\beta \in (0,1)$ is the time discount factor and $1/\gamma$ is the intertemporal elasticity of substitution.

The budget constraint is given by

$$C_t + K_t - (1-\delta)K_{t-1} = r_t K_t + w_t + T_t - \tau_t(r_t - \delta)K_t \tag{1.4.2}$$

where $\delta \in (0,1)$ is the rate of depreciation and $C_t \geq 0$. r_t and w_t denote the rental

rate of capital and wages respectively. We assume that in every period, agents supply one unit of labor inelastically. The government levies a tax on capital income (τ_t) and redistributes the tax revenue as a lump sum transfer (T_t) to the households. The tax allows a depreciation deduction.

The government balances its budget every period, which indicates that total revenue generated by the capital income tax is equal to the total transfer payments made by the government.

$$T_t = \tau_t(r_t - \delta)K_t \tag{1.4.3}$$

The representative firm faces the standard profit maximization problem and produces output Y_t using capital K_t according to the Cobb-Douglas production function,

$$Y_t = A_t K_t^{1-\alpha}(\mu)^{\alpha} \tag{1.4.4}$$

where $1 - \alpha$ is the share of capital in production and μ_t represents the deterministic trend. Therefore, the equations for returns to factors of production are given by:

$$r_t = (1 - \alpha)\frac{Y_t}{K_t} \tag{1.4.5}$$

$$w_t = \alpha Y_t \tag{1.4.6}$$

The transitory productivity shock as well as the fiscal shock (specifically, shock to capital income tax) is assumed to follow an AR (1) process in logs:

$$\log A_{t+1} = \rho_a \log A_t + \epsilon^a_{t+1}. \tag{1.4.7}$$

$$\log \tau_{t+1} = \rho_\tau \log \tau_t + \epsilon^\tau_{t+1}. \tag{1.4.8}$$

A competitive equilibrium is defined as a set of stochastic processes for A_t and τ_t as

well as quantities C_t and K_t that solves the consumer's and firm's decision problems.

Choice of Parameter Values

We use the model equations and the relevant data series to calibrate the key parameters of the model which are:

β: The Euler condition for consumption yields $\beta = \frac{1}{1+r}$. The annualized average of the real interest rate in India is roughly 2 percent, resulting in a value for $\beta = 0.98$.

δ: The capital stock series for India is obtained using the standard perpetual inventory method. The depreciation rate is computed by regressing the depreciation series on the capital stock resulting $\delta = 4.5$ percent. This is close to the value for depreciation rate assumed in the literature using annual data for India (Virmani, 2004), which is about 5 percent.

α: For the share of capital, we follow Virmani (2004) and set $1 - \alpha = 0.3$.

γ: We follow the literature and set the inter-temporal elasticity of substitution, $\gamma = 2$.

ρ_a and σ_a: We use two procedures to determine the parameters of the technology process. One, we follow NIPFP that uses the accounting method of Verma (2010) and extends the dataset to 2008 to compute the TFP series. They estimate the parameters of an AR (1) process as 0.92 and 0.005 respectively for persistence and standard deviation respectively.

In addition, we estimate the parameters governing the amplitude and persistence of the technology shock process in a basic model. In particular, we estimate ρ_a and σ_a by applying the generalized method of moments (GMM) using annual data on output, consumption and investment from India. We follow Cicco-Garcia, Pancrazi and Uribe (2009) and include 11 moment conditions: the standard deviations of detrended out-

put, consumption and investment, the correlation of output with consumption and investment and the first and second order autocorrelations of output, consumption and investment. The estimated parameter values are 0.9 and 0.05.

The parameters are listed in Table 1.5 below.

ρ_τ and σ_τ: We vary the parameters for the persistence and standard deviation of the shock process and report the investment output correlation statistic in Table 1.6.

Parameter	Value
$1-\alpha$	0.3
β	0.98
δ	0.05
γ	2
ρ_z	0.92
σ_z	0.005

Table 1.5: Parameters: Closed Economy

		ρ_τ	
		0.5	0.9
Std dev	0.01	0.88	0.87
	0.1	0.87	0.58

Table 1.6: Correlation between output and investment

1.4.2 Results and Discussion

Table 1.7 below reports the moments from the model and compares it to the actual data moments calculated earlier. The values of the parameters for the tax shock process are chosen so as to match the investment-output correlation in the data (i.e. around 0.5). We then check whether the tax series exhibits these properties.

	Data	Model
Volatility		
GDP	1.8	1.8
PC	1.4	2.8
PI	9.5	4.3
Relative Volatility		
GDP	1.0	1.0
PC	0.8	1.5
PI	5.3	2.4
Correlation		
GDP	1.0	1.0
PC	0.7	0.5
PI	0.6	0.6

Table 1.7: Business Cycle Statistics: Data and Model
Note: GDP = Private Output = Private Consumption (PC) + Private Investment (PI). In our benchmark closed economy framework, we focus exclusively on private components of C, I and Y.

We use two data series to describe the tax on capital income. In the first, we take the corporate tax reported by about 6500 companies listed on the Stock Exchanges in India for the years 1995–2010. This is divided by profits before tax to obtain the effective tax rate.[21] An AR (1) model is fitted to this data after detrending to obtain the persistence and standard deviation as 0.6 and 0.31 respectively.

The second series is corporation tax (in rupee crore) from 1951–2008, obtained from the Reserve Bank of India. Since we do not have a series for capital income, we assume that the share of capital income in total income (GDP) is 0.3 and use this to divide the tax series and obtain the tax rate. The persistence and standard deviation for the corresponding AR (1) model are 0.76 and 0.12 respectively.

In the model we assume that there is no correlation between the productivity shock and tax shock, to obtain a low correlation between output and investment. In order to check whether this is true in the data, we compute the correlations of the tax series with output, consumption and investment and compare them to results obtained from

[21]The data is obtained from Center for Monitoring the Indian Economy.

the model.[22] The first series, based on company data, does a better job of matching the moments of the data. However, the sign for the output-tax correlation is opposite in the model and the data.

In general, the tax series shows high volatility and persistence as required in the model. With regards to correlation, we obtain mixed results.

1.5 Small Open Economy Extension

1.5.1 Baseline Model

In this section we extend our benchmark closed economy and present a small open economy model along the lines of Schmitt-Grohe and Uribe (2003). The canonical small open economy model is plagued with a serious unit root problem concerning net foreign assets. This implies that purely transitory exogenous disturbances tend to have minor effects on current consumption but permanent effects on the net foreign asset position.

In their seminal paper, Schmitt-Grohe and Uribe propose five alternative theoretical constructs to circumvent the unit root issue. They also argue that the choice amongst these competing approaches depends purely on the research inquiry and computational convenience since their qualitative predictions do not vary much. Here we use a convex cost of portfolio adjustment (period asset holdings different from some long-run level) as a mechanism to pin down the steady state net foreign asset position and thereby ensure model stationarity.[23]

[22]Since DSGE models have been tested mainly for their ability to match second moments of the data, we compute the correlations of tax series with other macroeconomic variables and do not estimate the nature of the shocks.

[23]The baseline model is identical across all five approaches. The critical difference lies in the nature of household budget constraints and the corresponding optimization conditions.

The economy consists of a representative household that has preferences over the sequence of consumption C_t described by

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t \frac{[C_t - \omega^{-1} h_t^{\omega}] 1 - \gamma}{1 - \gamma} - 1 \tag{1.5.1}$$

where $\beta \in (0, 1)$ is the time discount factor, ω measures Frisch elasticity of labor supply, and $1/\gamma$ is the intertemporal elasticity of substitution.

The budget constraint is given by

$$d_t = (1 + r_{t-1}) d_{t-1} - Y_t + C_t + I_t + \Phi(K_{t+1} - K_t) + \frac{\psi}{2}(d_t - \overline{d})^2 \tag{1.5.2}$$

Where d_t denotes household borrowing (debt), Y_t is aggregate output, C_t is private consumption and I_t is total investment. ψ and $\overline{d}$ are constants governing the portfolio adjustment costs. Lastly, $\Phi(x)$ refers to quadratic capital adjustment cost denoted by:

$$\Phi(X) = \frac{\phi}{2} X^2 \tag{1.5.3}$$

We can rearrange the household budget constraint to reflect the components of aggregate output (national income) in this economy.

$$Y_t = C_t + I_t + \Phi(K_{t+1} - K_t) + \frac{\psi}{2}(d_t - \overline{d})^2 + (1 + r_{t-1}) d_{t-1} - d_t \tag{1.5.4}$$

where the last two terms on the right hand side represent the trade balance. Thus, aggregate output can be decomposed into consumption, investment, capital adjustment costs, portfolio adjustment costs and trade balance.

Output Y_t is produced using capital K_t and labor h_t according to the standard

Cobb-Douglas production function:

$$Y_t = A_t K_t^{\alpha} h_t^{1-\alpha} \tag{1.5.5}$$

Where α denotes the share of capital in production.

Capital stock evolves according to the following process:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{1.5.6}$$

Lastly, prevailing domestic interest rate (rate at which households borrow from the rest of the world) equals the world interest rate, as a small open economy takes the world interest rate as given.

$$r_t = r* \tag{1.5.7}$$

The transitory productivity (TFP) shock is assumed to follow an AR (1) process in logs:

$$\log A_{t+1} = \rho_a \log A_t + \epsilon_{t+1}^a. \tag{1.5.8}$$

We retain the original parameter values used by Schmitt-Grohe and Uribe.

Parameter	Value
α	0.32
r	0.04
δ	0.1
γ	2
ω	1.455
ϕ	0.028
ψ	0.00074
$\overline{d}$	0.7442
ρ_a	0.42
σ_ϵ	0.01

Table 1.8: Parameters: Open Economy

1.5.2 Open Economy: Discussion

Comparing the model moments with the data moments (computed earlier) at a glance leads to a few key insights. The benchmark small open economy model overestimates the volatilities of output, consumption and investment. However, the model seems to perform reasonably well in matching relative volatility of consumption (vis a vis output) as well as the correlations of private consumption and investment with output, when we focus exclusively on the post-reform period. Note that the model parameters are calibrated for the Canadian economy (as in Mendoza). This, coupled with the data deficiency to accurately calibrate all of India-specific parameters can partly explain this discrepancy.[24] It remains to be seen how the model performs under various parameter combinations so that we are able to draw appropriate qualitative inferences and quantitative predictions.

1.6 Comment on excluding labor from the model

Due to the lack of reliable and consistent data on employment, work hours, and wages, we assume that labor is inelastically supplied in the model. This means that we are abstracting from the choice between consumption and leisure that agents make when they face aggregate shocks. This could bias the results of the moments based on the current model. We try to understand the direction and extent of the bias by calibrating a model with variable labor and with fixed labor (one unit inelastically supplied) for US parameters and comparing the two sets of moments.

In the first model, the economy consists of a representative household that has

[24]The Indian economy most closely resembles a small open economy only in the post-reform period, which corresponds to the last two decades in our sample.

preferences over the sequence of consumption C_t described by

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma} \tag{1.6.1}$$

where $\beta \in (0,1)$ is the time discount factor and γ represents the intertemporal elasticity of substitution.

The budget constraint is given by

$$C_t + K_t - (1-\delta)K_{t-1} = Y_t \tag{1.6.2}$$

where $\delta \in (0,1)$ is the rate of depreciation. Output is produced using capital according to a Cobb-Douglas production function,

$$Y_t = (z_t)^{\alpha} K_t^{1-\alpha} \tag{1.6.3}$$

where z_t is the technology shock which follows an AR (1) process.

Agent's preference over consumption and labor in the second model is given by

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma} - \eta \frac{l_t^{1+\phi}}{1+\phi} \tag{1.6.4}$$

where $\frac{1}{\phi}$ is the Frisch elasticity of labor supply and η is the share of labor in utility. The production function is

$$Y_t = (z_t L_t)^{\alpha} K_t^{1-\alpha} \tag{1.6.5}$$

The parameters used in the calibration are given in the table below.

The model moments reported for output, consumption and investment are the standard deviation, the standard deviation relative to that of output and the contemporaneous correlation with output.

Parameter	Value
α	0.68
β	0.98
δ	0.05
γ	2
η	0.3
ϕ	3
ρ_z	0.9
σ_z	0.01

Table 1.9: Parameters

	Model with L	Model with $L = 1$
Volatility		
Y	0.059	0.047
C	0.051	0.039
I	0.097	0.077
Relative volatility		
Y	1.00	1.00
C	0.86	0.83
I	1.64	1.97
Correlation		
Y	1.00	1.00
C	0.99	0.98
I	0.96	0.96

Table 1.10: Moments from the Model

The results show that with inelastic labor, the volatility of output, consumption and investment are reduced. For example, in terms of moments, the standard deviation of output falls from 5.9 percent to 4.7 percent when the labor supply elasticity goes from 0.3 to zero. In a model with elastic labor, both the substitution and income effects of a wage change play a role in adjusting consumption, as the agent can choose between consumption and leisure. Flexible labor supply thus provides an extra margin of adjustment when analyzing the dynamic response of key macroeconomic variables to a productivity shock. In this case, the variation in output due to a transitory technology shock can be decomposed into variation in labor supply and changes in capital stock, which are of relatively smaller magnitude in the short run.

However, when the labor supply is fixed, we shut down the first channel thereby dampening the overall effect and reducing output volatility. King and Rebelo (1999) also show a reduction in the standard deviation of output and labor when the elasticity is reduced. Thus we can conclude that the results obtained in our benchmark model, when labor supply is assumed to be inelastic, underestimate the volatilities.

1.7 Conclusion

We document the main stylized facts of India's business cycles using longest available annual data. A key feature is that in India, investment and output are not highly correlated over the cycle; in contrast to what we see in developed countries.

In addition, we undertake two distinct empirical inquiries using our annual time series data. First, we investigate macroeconomic scenarios in India across various planning periods and second, we determine whether the economic reforms initiated in the year 1991 led to significant structural transformation in the Indian economy. Our analysis strongly supports the existence of a trend break (in the pre- versus post-reform India) based on strikingly different levels, growth rates as well as volatilities of key macro variables. We then proceed to test whether a simple business cycle model with technology and fiscal shocks can replicate the key stylized features of India's business cycles. Our results show that a high volatility of the tax rate shock is required to produce the low investment output correlation. With due acknowledgment of the tax data limitations, we use the available data and find a high volatility. The model seems to perform reasonably well in matching the correlation dynamics observed in the data. We also observe that by excluding labor movements from the model, our results underestimate the true volatilities of the specific macro variables.

Extensions to the model include introduction of a government sector that consumes

and invests as well as experimenting with alternative small open economy frameworks to identify which features specific to the Indian economy are critical in order to best capture its business cycle fluctuations.

India has indeed traveled a long way from being a highly regulated closed economy in the post-independence era to a vibrant emerging market of the current times. One must however keep in mind that India's reform journey is far from complete and the path is beset with challenges and obstacles. The Indian government ought to continuously identify and manage socioeconomic and sectoral problem areas to sustain and strengthen the pace of reforms.

1.8 Appendix I

Aggregate output (GDP) = Private Consumption (PC) + Government Consumption (GC) + Gross Capital Formation (I) + Net Exports (NX)

$$Y = C + I + NX \tag{1.8.1}$$

Note that in the Closed Economy version we assume NX = 0 and specifically focus on private consumption and private investment respectively.

Aggregate Consumption (C) = Private Consumption (PC) + Government Consumption (GC)

$$C = PC + GC \tag{1.8.2}$$

Private output (PY) = Private Consumption (PC) + Private Investment (PI)

$$PY = PC + PI \tag{1.8.3}$$

Gross Capital Formation by Sector :

Gross Capital Formation (GCF) = Household Investment (HH) + Private Corporate Investment (Corp) + Public Investment (Public)

Gross Capital Formation (GCF) = Gross Fixed Capital Formation + Change in Inventories.

	Data (HP)	USA (HP)
Volatility		
GDP	1.74	1.41
C	1.29	1.16
I	9.54	6.08
PC	1.36	1.13
GC	2.92	3.02
Relative Volatility		
GDP	1.00	1.00
C	0.74	0.82
I	5.47	4.31
PC	0.78	0.80
GC	1.67	2.14
Correlation		
GDP	1.00	1.00
C	0.79	0.72
I	0.24	0.87
PC	0.80	0.83
GC	0.18	0.14

Table 1.11: Business Cycle Statistics - India vs. USA

Share	Res	NonRes	PriI	Total I
1970–1991	5.8	8.6	14.0	18.4
1992–2012	4.6	11.5	16.5	20.7
1970–2012	5.2	10.0	15.2	19.5
Relative Volatility	Res	NonRes	PriI	Total I
1970–1991	6.81	2.63	4.27	3.43
1992–2012	6.88	4.29	5.33	4.04
1970–2012	6.83	3.17	4.59	3.61
Correlation	Res	NonRes	PriI	Total I
1970–1991	0.79	0.85	0.94	0.96
1992–2012	0.68	0.91	0.95	0.96
1970–2012	0.76	0.85	0.94	0.96

Table 1.12: Disaggregated Investment Dynamics: US

Note: The four columns represent residential, non-residential, private and gross domestic investment respectively. The idea is to depict the best possible correspondence between aggregate and sector wise investment statistics reported in India and the US.

Time Period	Y	C	I	PC	GC	NX
FYP1	266.81	216.44	93.29	153.66	64.25	
FYP2	252.39	184.36	109.29	141.92	49.72	
FYP3	224.73	126.86	23.24	134.90	17.06	
FYP4	304.08	191.63	60.25	169.13	29.85	
FYP5	275.20	161.12	118.61	157.94	14.90	
FYP6	286.71	199.45	101.97	168.73	42.19	
FYP7	887.24	492.76	270.03	395.55	104.91	
FYP8	1902.60	1382.06	1209.28	1117.07	266.61	
FYP9	1571.59	1028.03	987.89	899.52	160.49	
FYP10	658.93	382.88	1334.71	308.52	144.88	
FYP11	2169.70	1745.48	1167.54	1396.15	364.13	
Pvalue	0.00	0.00	0.00	0.00	0.00	
Pre-Reform	561.53	371.01	199.27	296.69	79.74	93.07
Post-Reform	1575.34	1176.60	1108.96	957.99	238.15	928.30
Pvalue	0.00	0.00	0.00	0.00	0.00	0.00

Table 1.13: Macroeconomic Volatility by Plan and Reform

Note: Values represent residual (error) Volatilities based on Stata's ROBVAR routine in order to check presence of group wise Heteroskedasticity in our macroeconomic time series. The p-values indicate the significance of relevant F statistic thus reflecting strong presence of Heteroskedasticity across various five year plans and also in the pre- and post-reform era.

Time Period	Ygr	Cgr	Igr	C/Y	I/Y	PC/Y	GC/Y
FYP1	3.96	3.93	4.02	91.69	13.08	86.06	5.63
FYP2	4.14	3.83	7.79	88.20	16.33	82.38	5.82
FYP3	3.49	3.38	7.94	86.11	19.00	78.42	7.69
FYP4	3.22	2.81	3.77	84.66	19.42	74.76	9.90
FYP5	3.29	3.48	5.37	82.78	20.60	72.70	10.09
FYP6	5.47	5.13	5.55	85.51	21.91	74.32	11.18
FYP7	5.85	4.78	7.65	82.26	23.21	69.68	12.58
FYP8	6.40	5.05	6.98	76.58	23.02	64.94	11.65
FYP9	5.52	5.42	9.92	75.22	25.33	62.66	12.56
FYP10	7.65	5.84	15.58	70.84	31.13	59.75	11.08
FYP11	7.05	7.60	8.50	70.19	38.59	59.12	11.08
Pre-Reform	4.11	3.81	5.35	85.78	19.27	76.88	9.10
Post-Reform	6.67	6.05	10.16	73.07	29.95	61.50	11.57

Table 1.14: Predicted Values based on Five Year Plans and Reforms

Note: Values are marginal predictions based on linear regressions involving five year plan and reform dummies.

1.9 Appendix II

1.9.1 Model solution: Closed Economy

Optimality conditions of the Household's problem

Assuming that the variables grow at the constant rate μ, we make the variables stationary. Define $y_t = Y_t/X_{t-1}$, $c_t = C_t/X_{t-1}$, $k_t = K_t/X_{t-1}$, $i_t = I_t/X_{t-1}$, and $tr_t = T_t/X_{t-1}$. Thus the constraints and the first order conditions are:

$$y_t = A_t k_t^{1-\alpha} \mu^{\alpha} \tag{1.9.1}$$

$$\mu k_{t+1} - (1-\delta)k_t = r_t k_t + w_t + tr_t - \tau_t(r_t - \delta)k_t - c_t \tag{1.9.2}$$

$$tr_t = \tau_t(r_t - \delta)k_t \tag{1.9.3}$$

$$(\frac{\mu}{c_t})^{\gamma} = \beta E_t \frac{1}{c_{t+1}^{\gamma}}[r_{t+1} - \tau_{t+1}(r_{t+1} - \delta) + 1 - \delta] \tag{1.9.4}$$

Steady State

$$\frac{y}{k} = \frac{1}{(1-\alpha)(1-\tau)}(\frac{\mu^{\gamma}}{\beta} - \delta(\tau - 1) - 1) \tag{1.9.5}$$

$$k = \mu(\frac{y}{k})^{-1/\alpha} \tag{1.9.6}$$

$$\frac{c}{k} = (1 - \tau(1-\alpha))\frac{y}{k} + \frac{tr}{k} + \delta(\tau - 1) - \mu + 1 \tag{1.9.7}$$

$$\frac{tr}{k} = \tau(1-\alpha)\frac{y}{k} - \delta\tau \tag{1.9.8}$$

$$\frac{i}{k} = \mu - 1 + \delta \tag{1.9.9}$$

Log-linearized Model

$$0 = -\hat{y}_t + (1-\alpha)\hat{k_{t-1}} + \hat{a}_t \tag{1.9.10}$$

$$0 = -\frac{c}{k}\hat{c}_t - \frac{i}{k}\hat{i}_t + \alpha\frac{y}{k}\hat{y}_t + \delta\hat{k_{t-1}} + (\delta + (1-\alpha)\frac{y}{k})\hat{\tau}_t + \frac{tr}{k}t\hat{r}_t \tag{1.9.11}$$

$$0 = (1-\alpha)\frac{y}{k}\hat{y}_t - \delta\hat{k_{t-1}} - \frac{tr}{k}t\hat{r}_t + ((1-\alpha)\frac{y}{k} - \delta)\hat{\tau}_t \tag{1.9.12}$$

$$0 = \mu\hat{k_t} - (1-\delta)\hat{k_{t-1}} - \frac{i}{k}\hat{i}_t \tag{1.9.13}$$

$$0 = E_t[\hat{c_{t+1}} - \hat{c}_t - \sigma\alpha(1-\alpha)\frac{y}{k}(\hat{a_{t+1}} - \hat{k}_t)] \tag{1.9.14}$$

1.9.2 Model Solution: Open Economy

First Order Conditions associated with C_t h_t K_t and d_t

$$[C_t - \omega^{-1}h_t^{\omega}]^{-\gamma} = \lambda_t \tag{1.9.15}$$

$$[C_t - \omega^{-1}h_t^{\omega}]^{-\gamma}h_t^{\omega-1} = (1-\alpha)\frac{\lambda_t Y_t}{h_t} \tag{1.9.16}$$

Substituting the expression for λ we have:

$$h_t^{\omega-1} = (1-\alpha)\frac{Y_t}{h_t} \tag{1.9.17}$$

$$\lambda_t[1 + \phi(K_{t+1} - K_t)] = \beta E_t\lambda_{t+1}[\alpha\frac{Y_{t+1}}{K_{t+1}} + 1 - \delta + \phi(K_{t+2} - K_{t+1})] \tag{1.9.18}$$

$$\lambda_t[1 - \psi(d_t - \overline{d_t})] = \beta(1 + r_t)E_t\lambda_{t+1} \tag{1.9.19}$$

The final optimality condition depicts the equality between marginal benefit of borrowing an extra unit of debt against its marginal cost. If the household chooses to borrow an additional unit, its current consumption increases by one unit minus the marginal cost of portfolio adjustment $\psi(d_t - \overline{d_t})$. The left hand side of the above equation reflects the value of this consumption increase in utility terms. Next period, the household must repay this additional unit of debt with interest $(1 + r_t)$. The burden of debt repayment in terms of today's utility sacrifice is given by the right-

hand side.

The four first order (optimality) conditions outlined above along with aggregate production function, law of motion for capital, equation determining domestic interest rate and the resource constraint constitute the system of 8 equations in 8 unknowns λ_t Y_t C_t, K_t, I_t, h_t, d_t, and a_t. We obtain the model solution by solving this system of equations.

Steady State

$$I_s = \delta K_s \tag{1.9.20}$$

$$d_s = (1+r)d_s + Y_s + C_s + I_s \tag{1.9.21}$$

$$Y_s = rd_s + C_s + I_s \tag{1.9.22}$$

$$C_s = Y_s - I_s - rd_s \tag{1.9.23}$$

$$h^{\omega} = (1-\alpha)Y \tag{1.9.24}$$

$$h^{1-\alpha} = [[(1-\alpha)Y]^{1/\omega}]^{1-\alpha} \tag{1.9.25}$$

$$\frac{Y}{K} = [\frac{h}{K}]^{1-\alpha} = \frac{r+\delta}{\alpha} \tag{1.9.26}$$

$$\frac{h}{K} = [\frac{r+\delta}{\alpha}]^{\frac{1}{1-\alpha}} \tag{1.9.27}$$

$$\frac{Y}{h} = [\frac{h}{K}]^{-\alpha} \tag{1.9.28}$$

$$\frac{Y}{h} = [\frac{\alpha}{(r+\delta)}]^{\frac{\alpha}{1-\alpha}} \tag{1.9.29}$$

$$K_s = \frac{h_s}{[(r+\delta)\alpha]^{\frac{1}{1-\alpha}}} \tag{1.9.30}$$

$$h_s = [(1-\alpha)[\frac{\alpha}{(r+\delta)}]^{\frac{\alpha}{1-\alpha}}]^{\frac{1}{\omega-1}} \tag{1.9.31}$$

1.9.3 GMM Estimation Procedure

Let $\theta = [\rho_a, \sigma_a]'$ be the 2×1 vector of structural parameters to be estimated. The moment conditions are written as:

$$u_t(\theta) = \begin{bmatrix} \sigma_y(\theta) - (y_t - \overline{y})^2 \\ \sigma_c(\theta) - (c_t - \overline{c})^2 \\ \sigma_i(\theta) - (i_t - \overline{i})^2 \\ \rho_{y,c}(\theta) - \frac{(y_t - \overline{y})(c_t - \overline{c})}{\sigma_y(\theta)\sigma_c(\theta)} \\ \rho_{y,i}(\theta) - \frac{(y_t - \overline{y})(i_t - \overline{i})}{\sigma_y(\theta)\sigma_i(\theta)} \\ \rho_{y1}(\theta) - \frac{(y_t - \overline{y})((y_{t-1} - \overline{y})}{\sigma_y^2(\theta)} \\ \rho_{y2}(\theta) - \frac{(y_t - \overline{y})((y_{t-2} - \overline{y})}{\sigma_y^2(\theta)} \\ \rho_{c1}(\theta) - \frac{(c_t - \overline{c})((c_{t-1} - \overline{c})}{\sigma_c^2(\theta)} \\ \rho_{c2}(\theta) - \frac{(c_t - \overline{c})((c_{t-2} - \overline{c})}{\sigma_c^2(\theta)} \\ \rho_{i1}(\theta) - \frac{(i_t - \overline{i})((i_{t-1} - \overline{i})}{\sigma_i^2(\theta)} \\ \rho_{i2}(\theta) - \frac{(i_t - \overline{i})((i_{t-2} - \overline{i})}{\sigma_i^2(\theta)} \end{bmatrix}$$

where $\sigma_x(\theta)$, $\rho_{xy}(\theta)$ and $\rho_{xj}(\theta)$ denote the standard deviation of x_t, the correlation between x_t and y_t and the autocorrelation of order j of x_t respectively, implied by the theoretical model. These are functions of the vector θ of structural parameters. We compute the moments implied by the theoretical model by solving a log-linearized system of equilibrium conditions. Define $Q = u'Wu$, where $u(\theta)$ denotes moment conditions and W is a symmetric positive definite matrix. The GMM estimate of θ denoted by $\widehat{\theta}$ is given by $\widehat{\theta} = argmin_\theta Q(\theta, W)$. Since the number of moment conditions exceed the number of estimated parameters, the weighting matrix W is updated optimally.

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Chapter 2

Institutions, Openness and Reserve Accumulation in Developing Countries

2.1 Introduction

2.1.1 Motivation

The era of financial integration in emerging and developing countries can be broadly compartmentalized into two distinct periods. The first phase in the 1990s is characterized by current account deficits, capital flow reversals (sudden stops) and financial and foreign exchange crises. The second period, kicked off in the 2000s,is marked by a secular rise in foreign reserve accumulation [Painceira (2009)].

Interestingly enough, capital has flowed from developing to developed markets during the past decade, as reflected in the net lending statistics. However, the most noteworthy aspect of these upstream international capital flows has been the monumental increase in international reserves held by several emerging economies. Reserve assets usually take the form of various kinds of deposits, securities, gold, repurchase

agreements and derivatives held by national monetary authorities. Current account surpluses and private capital flows serve as the sources of official (public) capital flows.

In a recent thought-provoking paper, Gourinchas and Jeanne (2013) show that the behavior of actual capital flows to developing countries is counterintuitive to the predictions of the neoclassical growth model. In other words, faster-growing developing economies tend to experience lower net capital inflows. In fact some of them are net capital exporters.

Public capital flows, in particular accumulation of international reserves, play a pivotal role in rationalizing this seemingly perverse capital allocation. Specifically, capital outflows from fast-growing developing nations can be directly linked to their policy of international reserve accumulation [Gourinchas–Jeanne (2011) Alfaro et al. (2012)]. In addition, Alfaro et al. observe that whereas private capital flows are broadly in sync with the standard neoclassical model, capital outflows from relatively high-productivity emerging markets can be explained by accumulation of reserve assets.

Several emerging and developing markets have been providing the rest of the world, and especially the United States, with net resources in the form of current account surpluses. This implies that a significant excess of domestic savings over investment has, as a rule, been a characteristic shared by all major reserve accumulators.[1]

In a nutshell, two stylized facts stand out from the current literature: Faster-growing developing countries are associated with lower net capital inflows and countries that grow faster accumulate more international reserves.

Reserve accumulation in most countries has gone beyond the levels warranted by conventional indicators, suggesting that the build-up is largely influenced by other

[1]Foreign reserves tend to be generally invested in the safest assets in global financial markets, which are issued mostly by the developed countries. US treasury securities are regarded as one of the most prominent reserve asset options.

factors. Three of the fundamental drivers of reserve accumulation, all of which can be linked to financial globalization, stand out namely; A. Desire to self-insure against sudden stops / financial crises (virtually all emerging markets share this motivation). B. Pursuit of export-led growth by a number of Asian economies, supported by an undervalued domestic currency. Reserves are utilized as a buffer against the impact of negative terms of trade shocks on exports and the real exchange rate, thereby facilitating adjustment of the current account. C. Combined effect of a number of features related to the financial structure of several emerging markets, including underdeveloped domestic financial systems and dollarization of foreign assets in certain net creditor Asian economies.

To sum up, reserve accumulation has had two key economic ramifications for developing countries. First, it has led to upstream capital flows, and second, it has caused a considerable increase in domestic debt for many developing countries, primarily due to the sterilization response.[2] In particular, Asian central banks have invested their international reserves heavily in US public debt since the early 2000s. This partly explains the connection between the US housing bubble (booming US financial market) during 2001–2007 and the international reserve holdings (excess savings) of developing countries.

This paper analyzes the core issue of reserve accumulation in developing countries both from empirical as well as theoretical perspectives. In particular, we focus on the following questions:

[2]Massive reserve accumulation coupled with a concomitant rise in developing country domestic debt can be attributed to the practice of sterilization to offset the potential inflationary impact of foreign inflows. As argued by Papadatos (2009), several developing countries were compelled to engage in sterilization so as to conform to the inflation targeting regime underlying the orthodox macroeconomic policy framework of the recent years. Simply put, these economies expanded their domestic borrowing not to channelize them into productive investment but to avoid resulting money supply increases causing deviations from the pre-set inflation targets.

1. What are the key patterns concerning reserve accumulation in emerging and developing countries over the last 2 decades (1990–2010), the golden age of financial globalization in the developing world?

2. Do we see any systematic variation across and between different regional clusters (Emerging Asia, Latin America, Central and Eastern Europe, Middle East and Africa) as well as across distinct income groups?

3. How can we explain key reserve accumulation patterns in developing countries through the lens of *institutional and financial heterogeneity*? As a precursor to this question, we provide empirical evidence supporting the claim that developing country groups exhibit substantial structural differences in terms of openness, institutions, and financial development.

4. Finally, how can we explain the relationship between institutional quality, financial development and reserve accumulation in a simple theoretical framework?

The paper is organized as follows. Section 2.2 provides an overview of the empirical methodology and detailed description of the data, shedding light on the main variables included in the empirical analysis. Section 2.3 covers three core elements of the empirical methodology. First, we summarize select results from the partition-based cluster analyses along with some robustness checks. Cross section regression analysis and some noteworthy observations are discussed next. Finally, we discuss a series of panel data models and summarize the key findings. Section 2.4 provides a literature review to place the ensuing theoretical inquiry in context. Section 2.5 presents the basic theoretical model, while Section 2.6 discusses some important comparative static exercises. Section 2.7 presents concluding remarks.

2.2 Data

We begin our empirical inquiry by compiling a dataset containing foreign reserve statistics, institutional quality measures and indicators of financial development and capital account openness for the majority of emerging and developing countries. Our country coverage is guided by our focus on reserve accumulation dynamics in the past two decades. A detailed country list along with the corresponding country codes, categorized by geographical area, is included in the appendix. This section provides a detailed description of the key economic, institutional and financial variables included in the analyses.

Financial Variables

We include the Chinn–Ito index (Chinn and Ito, 2006 and 2008) in our dataset as a measure of financial openness.[3] In addition, variables encapsulating various facets of a country's financial system (institutions and markets) are extracted from the Global Development Finance (GDF) Database (Demirguc-Kunt et al., 2012).[4] We choose seven variables from the GDF dataset based on the authors' recommendations of suitable benchmarking candidates as well as those with the most consistent data coverage for our sample.[5] Select variables and the financial development dimension they

[3]We use the most recent data update to this index, which contains time series data for 182 countries for the period 1970–2011. A higher value of the Chinn–Ito index reflects a greater degree of financial openness in an economy.

[4]GDF is an extensive dataset encompassing critical financial system characteristics for 205 economies spanning the past five decades (1960–2010). It builds on, updates, and extends previous efforts, in particular the data collected for the 'Database on Financial Development and Structure' by Beck, Demirguc-Kunt, and Levine (2000, 2010). The database also incorporates data from the Financial Access Survey, the Global Findex and Financial Soundness Indicators. Variables in this dataset can be classified into four broad measurement rubrics: (a) size of financial institutions and markets (financial depth), (b) degree to which individuals can and do use financial services (access), (c) efficiency of financial system in intermediating resources and facilitating financial transactions (efficiency), and (d) stability of financial institutions and markets (stability). This yields a 4x2 matrix of financial system characteristics.

[5]The GDF database underscores some important patterns emerging from cross-national analysis of financial systems namely; i. Financial systems are multidimensional. ii. Striking differences

measure are explained below.

1. Private Credit to GDP ratio (PrCrY1) denotes domestic private credit to the real sector by deposit money banks and other financial institutions as a percentage of GDP. Deposit money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits.[6] [Depth]

2. Financial system Deposits to GDP ratio (FinDepY) measures total deposit volume of the entire financial system (demand, time and saving deposits in deposit money banks and other financial institutions) as a fraction of a nation's GDP. [Depth]

3. Credit to Deposit ratio (CrDep) measures private credit extended by the deposit money banks as a share of their demand, savings, and time deposits. [Depth]

4. Net Interest margin (NetInt) is the accounting value of a bank's net interest revenue as a percentage share of its average interest-bearing (total earning) assets. It is calculated as (Interest Earned - Interest Paid)/ Average Interest Earning Assets.[7] [Efficiency]

5. Bank Z-score (BankZ) or distance to default is (ROA+equity/assets)/sd (ROA), where ROA is average annual return on end-year assets and sd (ROA) is the standard deviation of ROA. This variable explicitly compares buffers (capitalization and returns) with the potential for risk (volatility of returns). By

remain across regional groups and income levels. These regional aggregates mask considerable disparities amongst individual countries (within the same region/income set).

[6]We have also included a second narrower measure of Private Credit to GDP (PrCrY) reflecting private credit extended by the deposit money banks as a share of GDP. As evident from the definitions, these two measures of financial institution depth track each other fairly closely.

[7]Net interest margin assesses the success of a bank's investment strategy. In other words, a positive net interest margin indicates that the investment strategy is profitable, as interest returns outweigh the costs.

construction, it is inversely related to the probability of a financial institution's insolvency, i.e. the probability that the value of its assets becomes lower than the value of its liabilities. Simply put, a higher z-score implies a lower probability of insolvency. [Stability]

6. Stock market Capitalization to GDP ratio (StockCapY) is defined as the value of listed shares as a percentage of GDP. [Depth]

7. Stock market Turnover ratio (StockTurn) is the ratio of the value of total shares traded (transactions) to average real stock market capitalization (expressed as a percentage). The logic being, the higher the turnover (the more liquidity), the more efficient the market. [Efficiency]

Institutional Variables

The institutional quality measures are taken from a new dataset created by Kuncic (2014). In his innovative empirical research, Kuncic integrates more than 30 cross-national indicators underlining various dimensions of institutional quality and partitions them into three distinct groups based on subject category classification: legal, political, and economic. The central objective is to describe and compare different institutional classification systems and empirically operationalize key institutional concepts by bringing them to the data.

Kuncic also substantiates the claim that this three-way division is sufficient to encapsulate the formal institutional environment in a given country based on the factor analysis results (factor loadings and eigenvalues) as well as pairwise correlations. We use the relative country scores for two of the three measures (legal and economic) in our dataset.[8]

[8]Inter-country factor analysis (calculating latent factors for each year separately for all the sample countries) is performed to extract the true underlying institutional characteristics. This yields a measure of relative institutional quality: i.e. where does a specific country stand in relation to others? Standardized factor scores from Kuncic's final dataset are used as institutional quality indicators. His dataset also contains within-country absolute values of the three institutional quality

Economic Variables

The amount of foreign exchange reserves (minus gold) (R) is central to our analysis. Along with the absolute quantity of reserves, we also keep track of foreign reserves as a fraction of GDP (RY). Aggregate income and growth indices constitute the final set of economic variables. We use per capita GDP (PCY) and two notions of growth: The average annual growth rate of per capita GDP (PCYgr) as well as absolute GDP (Ygr) to capture the income and growth dynamics in our sample.[9]

A versatile and flexible methodology most suited for tracing cross-country variations in reserve accumulation is that of Cluster Analysis. It facilitates identification of structural heterogeneities amongst developing countries by dividing them into distinct groups based on institutional quality and level of financial development, which is one of our primary interests. Based on the nature of our dataset, we use the Kmeans cluster analysis routine in Stata.[10]

We condense all the available information by averaging across five distinct time windows: 1995–2010 (full sample), 1995–2000, 2001–2005, 2006–2010 (five year averages) and 2001–2010 (decade average). This provides a more nuanced snapshot of how (dis)similar these countries really are. We begin with a discussion of custer analysis results in the next section, followed by a systematic inquiry using both cross section as well as panel data models.

measures, based on scaled averages of raw indicators within each institutional category. However, as noted by Kuncic, this is a cruder approach compared to the systematic factor analysis and therefore needs to be used carefully.

[9]The data on economic variables is obtained from World Bank's World Development Indicator Database. Total foreign reserves minus gold, per capita GDP, and GDP growth rates (PCYgr and Ygr) are all expressed in current US dollars.

[10]Kmeans is a method of performing partition based cluster analysis. The user specifies the number of clusters, k, to create using an iterative process. Each observation is assigned to the group whose mean is the closest, and then based on that categorization, new group means are determined. These steps continue until no observations change groups. The algorithm begins with k seed values, which act as the k group means.

2.3 Empirical Methodology

2.3.1 Cluster Analysis: Results and Discussion

We approach the partition-based cluster analysis in two distinct ways. The first is a parsimonious cluster analysis which covers all the 44 countries in our sample but includes a restricted variable set (between three and five). We retain the main variable, foreign reserves (R), in each specification and alternate between the economic, financial and institutional variables in different variations. This simultaneously tests the robustness of the resulting cluster output. The second is a multidimensional (disaggregated) cluster analysis covering a marginally smaller number of countries (conditional on data availability) but including a maximum of eleven variables covering critical aspects of institutional and financial structure. We report a few representative cluster outputs in the appendix.

Several noticeable patterns emerge from the cluster analysis. The restricted-cluster analysis yields a five-cluster decomposition of the sample [see cluster snapshot 1 in the appendix]. Interestingly enough, BRIC nations along with newly industrialized Asian giants (Hong Kong, Korea and Singapore) as well as select Asian (Indonesia, Malaysia, Thailand) and Latin American (Mexico, Argentina) countries are placed at the top end of the cluster in terms of reserve accumulation. However, three out of the five clusters together cover less than a third of our total sample. The bottom two clusters are the largest (with 31 members) and include most of the countries in Central and Eastern Europe (except Poland, Turkey), Middle East-Africa and Latin America (except Argentina, Brazil, Mexico). Very few (relatively less developed) Asian countries find themselves in the lower half of the reserve accumulation hierarchy (Nepal, Bangladesh, Pakistan). This provides the first piece of empirical evidence in favor of regional variations in reserve accumulation, with newly industrialized and emerg-

ing Asia as clear outliers. The multidimensional cluster analysis with five clusters seems broadly in line with its restricted counterpart. When we impose the four-cluster division, the largest two clusters are mapped into one big group, preserving the memberships in the other three clusters. (see cluster snapshot 2).[11]

The most striking fact is that China emerges as the only country with its own (separate) cluster in almost all our cluster trials. Moreover, this single-member cluster assignment is preserved in almost all bundles of institutional, financial, and economic variables as well as all but two temporal aggregations (by decade, by five year time windows, full sample). This highlights China's truly unique reserve accumulation experience, especially in the last decade, which clearly warrants special treatment.[12]

Descriptive statistics (presented in the appendix) based on the cluster outputs reveal some important stylized facts. A dichotomy is evident between the high growth countries with relatively closed (restricted) capital accounts versus slow-growing but relatively open developing nations. The first set is at the top and the other at the bottom of the reserve accumulation ladder. The relevant scatter plots linking reserve dynamics with growth and financial openness also seem to support this pattern.

Next, we concentrate on the temporal evolution of reserve dynamics by focusing on three five-year windows, the recent decade and the full fifteen year time series [see cluster snapshots 1, 4 and 5 in the appendix]. Which countries (if any) change cluster memberships over time and why is a natural question in this context.

The most noteworthy feature is that China and Singapore belonged to the same cluster in the early part of our sample period (until the late 1990s) as reflected in the first five-year window and the first decade. Thereafter, China branched out on

[11] Argentina appears to be the only exception, changing cluster memberships based on the specification of number of clusters(k).

[12] We also ran our analysis without China. The resulting cluster assignments are easily comparable with those including China by simply reducing the cluster number by one. This reflects the near impossibility of combining China with any other country in our sample.

its own beginning in the early 2000s whereas Singapore joined the ranks of newly industrialized Asian countries. Moreover, during the 1990s, the BRI countries (Brazil, Russia, and India), newly industrialized Asian economies and other emerging nations in Asia, Latin America and Eastern Europe (Singapore, Korea, Malaysia, Mexico, Indonesia, Thailand, Turkey, Poland) were grouped together. However, the past decade has seen a marked difference in reserve dynamics between the BRI countries, Korea, and Singapore from their emerging counterparts thus leading to a segmentation of the big cluster into two. Also, the relatively recent emergence of Brazil as a leading reserve holder in Latin America is noteworthy. Interestingly enough, several countries in Central and Eastern Europe, Latin America, Africa and Middle East have retained their original cluster associations over time. Finally, the cluster composition in the 2000s is more skewed (one big, two small, and a single-country cluster) compared to the 1990s (two big, one medium, and a two-country cluster).

To test the accuracy and optimality of our cluster results, we undertake a series of robustness checks using a wide range of variable combinations and several values of K (number of clusters). We now discuss the sensitivity analysis results in brief.

In the parsimonious model, using either per capita income (PCY) or the average annual GDP growth rate (Ygr) or both together in the cluster algorithm does not change the cluster assignments. In addition, when we assign K=3 or K=5 (instead of 4), the two large clusters merge into a single cluster or the largest cluster gets split into two, with identical cluster sizes as the benchmark case of K=4.

In case of the multidimensional cluster model, we include alternate measures of income (per capita GDP / average annual GDP growth), sequentially drop one of the three institutional quality indicators (legal, political, economic) from the specifications, and experiment with several sets of financial development measures (reflecting depth, efficiency, stability of financial institutions and markets). In each of these nine

iterations, the cluster memberships are broadly preserved. We also repeat all the exercises for K = 5 instead of 4. As a result, the largest group (when K = 4) is split into two groups (N = 16 and 12).[13] Lastly, we employ the absolute distance metric (L1) as the cluster (dis)similarity measure and compare the output against the default measure of Euclidean distance (L2). No significant changes in cluster sizes and memberships are observed. In particular, some clusters memberships (and sizes) are identical across all variable sets: e.g., China (single country cluster), Brazil, Russia, India, Korea and Singapore (high growth emerging/newly industrialized counties) as the second cluster and Indonesia, Malaysia, Thailand, Mexico, Poland, and Turkey closely following them.

To conclude, several variable combinations yield qualitatively similar cluster results. This can be partly explained using the pairwise correlation matrix based on Spearman's rank correlation method. Many variables belonging to a particular group [institutional quality indicators and financial development measures] display positive correlations with each other. Therefore, replacing one with the other or creating an aggregate index using all of them does not alter the final cluster outcomes significantly.[14]

To shed light on the relationship between key financial, institutional, and economic variables with foreign reserve dynamics, we create a series of scatter plots.[15] Several striking observations come to the fore as we carefully inspect each scatter set.

The scatter diagrams broadly confirm the positive association between economic growth and reserve accumulation for the developing world as a whole. In particular,

[13] We also tried K = 3 and 6. In the cluster literature, a trade-off between larger K versus analytical precision is often discussed. In light of this debate, we regard K = 4(or 5) as a reasonable choice.

[14] The entire rank correlation matrix is presented in the appendix.

[15] Each set of scatter diagrams focuses on the link between reserves and a specific variable, viewed through the lens of non-overlapping time aggregates e.g. full sample, five year windows and the most recent decade. The appendix presents select scatter plot sets, each depicting the relative position of the four country clusters, as identified in the cluster analyses earlier.

developing countries which have consistently reported strong GDP growth rates are also among the largest reserve holders. Moreover, this is true not just for the absolute amount of foreign reserves but also for the relative reserve share [see Figures 1,2 and 3].[16] Interestingly enough, the degree of financial openness (captured by the Chinn–Ito index) has a negative association with cumulative reserve holdings for each of the time aggregations chosen. Moreover, this inverse relation seems to have gradually intensified in the last decade (more so since the mid-2000s.) In other words, countries with more open capital accounts have accumulated modest quantities of international reserves (barring a few exceptions, most notably Singapore). In contrast, some of the leading reserve holders are countries with a relatively closed capital account.This trend has become more pronounced during the past decade (see Figures 2.4a and 2.4b).

The association between institutional quality and reserve accumulation is more complex. This is not unexpected, given the complications associated with measuring different categories of institutions (legal, political, economic) and their operational efficiency. On one hand, quality of legal institutions seems to exert some positive influence on reserve holdings. On the other hand, the relationship between economic institutions and reserve dynamics is somewhat ambiguous irrespective of the time classification used [see Figures 2.5a, 2.5b and 2.6a, 2.6b]. Furthermore, there exists marked heterogeneity as far as the link between reserve accumulation and a country's legal foundation is concerned. In other words, when we inspect countries with relatively underdeveloped legal institutions, both extremes co-exist: those holding substantial reserves as well as those at the bottom end of the reserves scale. Variables measuring different aspects of financial development (depth, efficiency, and stability) are considerably different in terms of their relationship with foreign reserves

[16]We experimented with both nominal GDP as well as per capita GDP growth rates to measure economic growth. The qualitative results are preserved.

[see Figures 2.7a, 2.7b, and 2.7c]. Whereas depth of the financial system (proxied by private credit extended by the financial system or stock market capitalization) seems to be positively linked with reserve holdings; the reverse is true as far as financial institution efficiency is concerned. In other words, several countries with large net interest margin (indicative of a successful financial investment strategy) do not seem to be reporting large foreign reserve volumes and vice versa. The link between financial stability (Bank Z-score) and reserves is even more intriguing. The top tier of reserve accumulators consists of two extremes: countries with relatively stable as well as vulnerable financial systems.

Thus, a bird's eye view of the scatter plots encapsulating various dimensions of income, institutional quality and financial development points towards the resounding presence of structural heterogeneity in our sample. We investigate it further in the next two subsections.

2.3.2 Cross Section Analysis

Cluster analyses as well as the scatter plot series, albeit informative, serve as precursors to a more rigorous statistical inquiry. Therefore, we treat them as the first step in uncovering the underlying trends in our data. The objective of regression analysis is two-fold. First, to detect the presence of cluster and regional heterogeneity with respect to openness, institutions and financial development. And second, to examine the relative importance of structural heterogeneity in explaining observed patterns of reserve accumulation.

For the cross section regressions with five different time aggregates we begin with the rudimentary specification, including just the main effect of explanatory variables. In the panel data models, described in the next subsection, we gradually transition to an extended specification incorporating cluster and regional interactions.

Basic linear regression framework of the form $Y = \alpha + \beta X + \epsilon$ is employed in the cross section models. The dependent variable Y in all model variants is log of Reserves. X is a vector of independent variables that vary across models (different combinations of financial, institutional, and economic indicators). Tables 2.1a, 2.1b and 2.1c present the main results of the cross section models. Let us describe the key findings in detail.[17]

- Impact of income per capita on reserve accumulation is positive and highly significant across all five periods. In addition, higher GDP growth is associated with higher reserve holdings in the latter half of our sample (specifically during the past decade).

- Contrary to the effect of income, more financial openness (measured by improvement in the Chinn–Ito index) has a consistent, negative relationship with reserve holdings for all time periods under consideration.

- Of all the financial variables, two seem to matter in particular for reserve dynamics in the cross section context: stock market capitalization to GDP ratio and stock market turnover ratio, indicative of financial market depth and efficiency respectively.

- Furthermore, the model testing the effect of institutional quality on reserve accumulation yields strikingly mixed results. While legal institutions have a mildly positive impact on reserves, the quality of economic institutions exerts a strong negative influence on reserve accumulation across the board. How and why certain less financially open countries with relatively inferior economic institutions tend to amass large volumes of foreign reserves is an intriguing

[17] Cheung, Ito(2009) investigate the key determinants of international reserves using a sample of major developed as well as developing countries. Our empirical approach, however, is considerably different not only in terms of country coverage, time-period, and variable selection but also in the use of cluster analysis as a unique way of partitioning the sample into groups of relatively similar countries. Moreover, we employ panel data specifications in addition to our cross-section models.

question both from an academic as well as policy standpoint.

In a nutshell, income, institutions, openness and financial market indicators play an important role in explaining cross-national variation in reserve accumulation. Having said that, some caveats involved in the cross-section framework need to mentioned. Our basic model assumes one β for the entire country sample. By forcing coefficient uniqueness this way, we are unable to capture the effects conditional on cluster memberships and regional groups. We tackle different dimensions of country heterogeneity in the next subsection with more elaborate panel data models.

Table 2.1a: Growth, Openness and Reserves

	F1	F2	F3	D2	Full
PCGDP	0.97***	0.96***	1.02***	1.03***	0.97***
	(0.22)	(0.25)	(0.25)	(0.24)	(0.22)
GDP growth	0.16	0.03	0.22**	0.24*	0.38***
	(0.10)	(0.10)	(0.11)	(0.14)	(0.12)
FinOpen Index	-0.42**	-0.57***	-0.49***	-0.57***	-0.84***
	(0.17)	(0.17)	(0.16)	(0.16)	(0.15)
Observations	44	44	44	44	40

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.1b: Institutions and Reserves

	F1	F2	F3	D2	Full
PCGDP	1.31***	1.25***	0.85**	1.03***	1.17***
	(0.36)	(0.36)	(0.35)	(0.36)	(0.34)
Inst-Legal	-0.19	1.49**	1.20**	1.41**	0.98*
	(0.53)	(0.56)	(0.53)	(0.56)	(0.55)
Inst-Economic	-1.09**	-2.26***	-1.46***	-1.91***	-2.13***
	(0.47)	(0.55)	(0.51)	(0.55)	(0.52)
Observations	41	42	42	42	40

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The five model headers correspond to the specific time aggregates we consider namely; three five-year windows 1995-2000, 2001-2005, 2006-2010, the most recent decade 2001-2010, and the full cross section period 1995-2010. Dependent variable is Reserves minus gold (log). The explanatory variables are per capita income (log), average annual GDP growth and the Chinn-Ito index (proxy for financial openness) and quality of legal as well as economic institutions in a particular country relative to others. The sample size varies slightly in each scenario based on data availability.

Table 2.1c: Financial Development and Reserves

	F1	F2	F3	D2	Full
PCGDP	0.32*	0.26	0.47**	0.38**	0.33
	(0.18)	(0.20)	(0.18)	(0.18)	(0.20)
Net Interest Margin	-0.02	0.07	0.15	0.26*	0.24**
	(0.08)	(0.12)	(0.15)	(0.13)	(0.11)
Stock Cap to GDP Ratio	0.32	0.42*	0.33*	0.38*	0.37*
	(0.20)	(0.21)	(0.19)	(0.19)	(0.19)
Stock Turnover Ratio	0.56***	0.58***	0.65***	0.65***	0.72***
	(0.14)	(0.14)	(0.15)	(0.15)	(0.17)
Observations	39	39	41	41	40

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: The five model headers correspond to the specific time aggregates we consider namely; three five-year windows 1995-2000, 2001-2005, 2006-2010, the most recent decade 2001-2010, and the full cross section period 1995-2010. Dependent variable is Reserves minus gold (log). The explanatory variables are per capita income (log), net interest margin, stock market capitalization to GDP and stock market turnover ratio (both in logs). The sample size varies slightly in each scenario based on data availability.
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2.3.3 Panel Data Analysis

Our extended panel dataset includes 44 countries over the last 20 years (1990–2010). This set-up is particularly advantageous, as we can explicitly introduce time effects to capture the impact of global macroeconomic events (common to all countries) on the temporal evolution of reserve accumulation. In addition, this framework facilitates the inspection of cluster-based as well as regional heterogeneity by including their interactions with select financial, institutional, and economic variables. We can thus retain the intra-cluster similarity as well as separately factor in inter-cluster variations to better understand individual country experiences with reserve holdings and any generic patterns reflected in the data. For comparison purposes, we start our panel data analysis with the same baseline specification as in the cross section models (just the main effects). We employ fixed effects regression models and include time dummies for the three (non-overlapping) five year windows 1995–2000, 2001–2005 and 2006–2010. Tables 2.2a provides a result snapshot of the baseline model.

Consistent with the cross section models, income per capita continues to be positively linked with reserve accumulation. Moreover, improvements in financial openness and quality of legal institutions have a weakly negative and positive impact on reserve holdings respectively. However, contrary to the cross section results, the quality of economic institutions is positively associated with reserve dynamics in developing countries. Also, several aspects of financial development such as financial institution depth (private credit to GDP ratio, financial system deposits to GDP ratio) as well as financial market depth and efficiency (stock market capitalization to GDP and stock turnover ratio) seem to matter for reserve accumulation. Lastly, all three time dummies are highly significant across all model variants. The effects intensify over time underlining the increasing relevance of global macroeconomic phenomena in explaining reserve accumulation in the developing world.

Table 2.2a: Income, Institutions and Reserves I

	Model1	Model2	Model3	Model4
PCGDP(log)	1.07***		1.06***	
	(0.07)		(0.07)	
GDP Growth		0.01***		0.02***
		(0.00)		(0.00)
FinOpen Index	-0.04**	-0.02		
	(0.02)	(0.02)		
Inst- Legal	0.12**	0.10*		
	(0.05)	(0.06)		
Inst-Economic	0.11**	0.33***		
	(0.05)	(0.06)		
PrCrY Ratio(log)			0.43***	
			(0.07)	
FinDepY Ratio(log)				0.86***
				(0.09)
CrDep Ratio (log)			-0.67***	0.16**
			(0.09)	(0.08)
StockCapY(log)			0.06**	0.07**
			(0.03)	(0.03)
StockTurnover(log)			0.09***	0.11***
			(0.02)	(0.02)
Time1:1995-2000	0.41***	0.72***	0.32***	0.48***
	(0.05)	(0.05)	(0.05)	(0.06)
Time2:2001-2005	0.86***	1.37***	0.61***	0.91***
	(0.06)	(0.06)	(0.06)	(0.07)
Time3:2006-2010	1.12***	2.27***	0.79***	1.60***
	(0.09)	(0.06)	(0.09)	(0.08)
Observations	803	803	674	673

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable in all models is Reserves minus gold (log). The explanatory variables are different combinations of economic, financial and institutional variables explained in the data section. The last three rows capture the impact of global macroeconomic events (during the three five year windows) on reserve accumulation.

As noted in the previous subsection, there is no a priori reason to expect that the effects of financial, institutional, and economic variables on reserve accumulation are identical for all developing countries. We are interested in identifying whether the effects of income, institutions and openness vary based on cluster-affiliation and geography. Shutting off the cluster-specific variation by combining their effects into a unique coefficient could lead to misleading inferences and is therefore clearly sub-optimal. This sets the stage for augmenting our basic model to include cluster-interactions. A summary of panel data models with cluster effects is presented in Table 2.2b and 2.2c.[18]

Several interesting observations arise from these extended panel models:

- GDP per capita stands out as a strong positive influence on reserve accumulation for each of the four clusters in our sample. In particular, effect of PCY on reserve volumes is the strongest in case of China and other high growth emerging markets (BRI nations + newly industrialized Asian economies) representing clusters 2 and 3 respectively.

- Degree of financial openness is positively associated with reserve accumulation in China and other high-growth Asian + BRI nations and has a mildly negative impact on reserve accumulation in cluster 4 (the largest group in our sample mainly composed of countries in CEE, LatAM and MENA).

- Most notably, quality of economic institutions in China and other high-growth Asian + BRI economies is negatively associated with reserve accumulation in these countries. The impact is quantitatively substantial, particularly for China. On the contrary, quality of economic institutions seems to be weakly favorable for reserve holdings in the remaining two clusters.

[18]We experimented with cluster interactions of all the variables from our original specification. However, based on their significance and explanatory power we have retained a subset of them in the final specification.

- Depth of financial institutions (proxied by private credit to GDP ratio) is positively related to reserve accumulation in all the clusters except for China. Magnitude of this effect is the largest in case of high-growth Asian + BRI economies (cluster 3).

- Depth and efficiency of financial markets (measured by stock market capitalization to GDP and stock turnover ratio) is positively linked with reserve dynamics in almost three-fourth of our sample (represented by clusters 3 and 4), except in case of China, Mexico, Poland, Turkey and some nations in emerging Asia.

- Finally, the secularly rising magnitude of time effects (preserved across all specifications) reflects the increasing relevance of global macroeconomic developments in explaining reserve accumulation dynamics recent times.

In addition to the cluster-specific effects explained above, we also examine how the impact of income, openness and institutions varies by geography. These regional interactions provide a second vantage point to decipher the underlying trends in reserve accumulation in our data. They also complement the cluster effects examined earlier. We create five regional dummies for Africa, Asia, Central and Eastern Europe (CEE), Latin America (LatAm) and Middle East- North Africa (MENA) and interact them with key explanatory variables. Then we use these extended variable sets in a series of regression models. Tables 2.3a through 2.3h depict panel results with regional effects.

Key observations emerging from the regional interactions help shed light on the subtleties of cluster-variation with respect to reserve accumulation. To begin with, the robust effect of per capita income on reserve holdings seems to be guided by its sizable magnitude in case of Africa, Asia, and CEE. Also, degree of financial openness seems to positively affect reserve volumes in Africa, CEE and Asia (though the effect is not quantitatively large.) but has a weakly negative impact in case of

reserve accumulation by Latin America. This regional dichotomy can partly reconcile the seemingly inconclusive cross section and panel results reported earlier. Relative quality of legal institutions has a two-fold impact on reserve dynamics; strengthening reserve holdings in Africa and Latin America and dampening reserve volumes in CEE as well as MENA countries.

As far as the financial development indicators are concerned, depth of financial institutions (private credit to GDP and financial system deposits to GDP ratio) has a sizable positive payoff for reserve accumulation in Africa, Asia and CEE but not so much for Latin America and MENA. In addition, depth and efficiency of stock markets (capitalization to GDP and turnover ratio) matter the most in case of Africa and Asia.

To sum up, income, openness, institutional quality, and financial development play an instrumental role in explaining the underlying patterns of reserve accumulation in the developing world. Moreover, impacts of these structural parameters vary considerably by cluster (relatively similar countries) and geography, not only in terms of their magnitude (strong/mild) but also by direction (positive/negative).

Table 2.2b: Income, Institutions and Reserves II - Cluster Effects

	Model1	Model2	Model3
Cluster1#PCGDP	0.67***		
	(0.11)		
Cluster2#PCGDP	1.35***		
	(0.19)		
Cluster3#PCGDP	1.48***		
	(0.12)		
Cluster4#PCGDP	0.98***		
	(0.08)		
Cluster1#FinOpen Index	0.02	0.00	0.01
	(0.06)	(0.07)	(0.07)
Cluster2#FinOpen Index	-0.07	1.40***	1.34***
	(0.48)	(0.46)	(0.45)
Cluster3#FinOpen Index	0.07	0.22**	0.26***
	(0.09)	(0.10)	(0.10)
Cluster4#FinOpen Index	-0.05**	-0.03	-0.03
	(0.02)	(0.03)	(0.03)
Cluster1#Inst-Economic	-0.07	0.32**	0.33***
	(0.11)	(0.13)	(0.13)
Cluster2#Inst-Economic	-0.21	-2.29***	-2.29***
	(0.70)	(0.60)	(0.61)
Cluster3#Inst-Economic	-0.54**	-0.55*	-0.69**
	(0.25)	(0.29)	(0.29)
Cluster4#Inst-Economic	0.19***	0.37***	0.38***
	(0.06)	(0.06)	(0.06)
Inst-Legal	0.09*	0.11*	0.09
	(0.05)	(0.06)	(0.06)
Time1: 1995-2000	0.41***	0.72***	0.70***
	(0.05)	(0.06)	(0.06)

Time2: 2001-2005	0.87***	1.35***	1.34***
	(0.07)	(0.07)	(0.07)
Time3: 2006-2010	1.17***	2.26***	2.25***
	(0.10)	(0.07)	(0.07)
Cluster1#GDP Growth		0.01	
		(0.01)	
Cluster2#GDP Growth		-0.03	
		(0.04)	
Cluster3#GDP Growth		0.04***	
		(0.01)	
Cluster4#GDP Growth		0.01**	
		(0.01)	
Observations	773	773	773

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable in all three models is Reserves minus gold (log). The explanatory variables are interactions of four country clusters with per capita income (log), average annual GDP growth the Chinn-Ito index (proxy for financial openness), and relative quality of economic institutions in a particular country vis a vis its other developing counterparts. Legal institution quality is included as a normal control since the corresponding cluster effects are not particularly significant. The time effects for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 capture the effects of global macroeconomic events (common for the entire sample) on reserve accumulation.

Table 2.2c: Financial Development and Reserves - Cluster Effects

	Model1	Model2	Model3
Cluster1#PCGDP	0.88***		
	(0.11)		
Cluster2#PCGDP	1.60***		
	(0.50)		
Cluster3#PCGDP	0.54**		
	(0.22)		
Cluster4#PCGDP	1.03***		
	(0.09)		
Cluster1#GDP Growth		0.01	
		(0.01)	
Cluster2#GDP Growth		-0.01	
		(0.12)	
Cluster3#GDP Growth		0.03**	
		(0.01)	
Cluster4#GDP Growth		0.01**	
		(0.01)	
Cluster1#PrCr to GDP	0.37**		
	(0.17)		
Cluster2#PrCr to GDP	0.26		
	(1.18)		
Cluster3#PrCr to GDP	1.29***		
	(0.36)		
Cluster4#PrCr to GDP	0.39***		
	(0.09)		
Cluster1#Deposit-GDP		0.50**	0.05
		(0.22)	(0.30)
Cluster2#Deposit-GDP		0.29	0.96
		(1.73)	(1.70)
Cluster3#Deposit-GDP		1.30***	1.85***
		(0.36)	(0.47)
Cluster4#Deposit-GDP		0.89***	0.70***
		(0.10)	(0.12)
Cluster1#Credit-Deposit	-0.80***	-0.11	0.26
	(0.18)	(0.14)	(0.19)

Cluster2#Credit-Deposit	-0.07	-3.79	-2.44
	(2.42)	(4.96)	(2.56)
Cluster3#Credit-Deposit	0.02	1.32***	1.06**
	(0.29)	(0.30)	(0.49)
Cluster4#Credit-Deposit	-0.65***	0.13	0.32***
	(0.13)	(0.11)	(0.12)
Cluster1#StockCap-Y	-0.06	0.00	-0.28***
	(0.07)	(0.08)	(0.11)
Cluster2#StockCap-Y	-0.06	0.26	0.38
	(0.28)	(0.43)	(0.27)
Cluster3#StockCap-Y	0.41***	0.31**	-0.09
	(0.14)	(0.14)	(0.16)
Cluster4#StockCap-Y	0.08***	0.07*	0.18***
	(0.03)	(0.03)	(0.06)
Cluster1#StockTurnover	0.06	0.15**	
	(0.07)	(0.07)	
Cluster2#StockTurnover	-0.09	0.30	
	(0.30)	(0.29)	
Cluster3#StockTurnover	0.29***	0.29***	
	(0.10)	(0.11)	
Cluster4#StockTurnover	0.08***	0.09***	
	(0.02)	(0.02)	
Net Interest Margin			-0.02*
			(0.01)
Stock Turnover Ratio			0.05*
			(0.03)
Time1: 1995-2000	0.32***	0.46***	
	(0.06)	(0.06)	
Time2: 2001-2005	0.60***	0.87***	0.42***
	(0.07)	(0.07)	(0.05)
Time3: 2006-2010	0.82***	1.56***	1.09***
	(0.09)	(0.08)	(0.06)
Observations	638	638	451

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are select financial development indicators explained in the data section. The last three rows correspond to the time effects (for each of the five-year windows defined earlier) capturing effects of global macroeconomic events on reserve accumulation.

2.4 Relevant Literature

In the late 1980s and early 1990s, emerging economies embraced widespread financial liberalization. However, in the efforts to balance the twin goals of exchange rate stability and monetary independence, many of them experienced severe financial crises. In the aftermath of such financial turmoil, many emerging markets have adopted the policy mix of managed (flexible) exchange rate regime, coupled with continued financial integration while maintaining domestic monetary sovereignty. Hoarding of substantial international reserves has become the hallmark of developing countries in general and emerging Asia, in particular. These countries are still engaged in exchange rate management to a considerable extent. Combating upward pressure on their domestic currencies amid concerns about preserving monetary stability has compelled them to complement international reserve accumulation with aggressive sterilization measures.

Reserve accumulation, decidedly, has monetary implications. Once the decision to accumulate foreign reserves is made, how to fund this purchase is the next question. One option is to increase the monetary base, which is potentially inflationary. The alternative is to reduce net domestic assets in order to sterilize the impact of reserve accumulation on the monetary base and eliminate the resulting inflationary impact. Specifically, when foreign reserve asset purchase is accompanied by inflationary pressures via increase in the base money, monetary authorities (central banks) step in.

The intervention is captured by sterilizing the excessive liquidity creation to mitigate inflationary forces and associated real exchange rate appreciation, as well as to avoid sacrificing domestic monetary control. Policymakers often rely on contractionary monetary policy such as open market sales, increased reserve requirements and/or window guidance (direct control on credit volumes of selected banks) to off-

set the potential inflationary impact of foreign capital flows. In particular, central banks sell treasury bills or central bank paper to the domestic private sector so as to neutralize some or all of the monetary expansion associated with accumulation of foreign exchange reserves (sterilized intervention). Other sterilization measures include raising banks' statutory minimum reserve requirements or increasing discount rates.[19]

Recent research by Aizenman and Glick (2009) points towards the intensification in the degree of sterilization practiced by several economies in Asia and Latin America. The authors undertake a rigorous empirical investigation of changing sterilization dynamics within the emerging markets as they continue to make strides in the process of financial liberalization. Their central empirical result underscores the fact that the extent of sterilization of foreign reserve inflows has risen in recent years to varying degrees in Asia as well as Latin America. Moreover, their econometric analysis detects important structural shifts in the pattern of reserve hoardings by developing countries, one in the early 1990s (increasing Reserves to GDP ratio) and the other in the early 2000s: a monumental increase in international reserve holdings by China.

In the case of China, extent of sterilization was relatively mild until the early 2000s. Since mid-2002, China's foreign reserve inflows rose sharply, accompanied by negative changes in domestic asset holdings by the central bank reflecting a tight money policy. This provides strong evidence for active sterilization practiced in China. Similar sterilization experiences have been reported in other Asian countries such as Korea, Thailand, Malaysia, and India, and also in select Latin American countries namely; Brazil, Argentina and Mexico.[20]

[19]Hagiwara (2004) highlights the policy dilemma associated with reserve sterilization using India and China as case studies. In India, open market operations and continuous repo operations under the Liquidity Adjustment Facility have been conducted to sterilize the impact of substantial US dollar purchases on domestic reserve money. Net sales of government dated securities issued by the Reserve Bank of India reached its peak in late 2003 amounting to Rs.139 billion.

[20]They employ a simple regression specification of change in net domestic assets on change in net foreign assets (both scaled by the monetary base and change computed over four quarters) so

Reserve accumulation and accompanying sterilization can exacerbate financial distortions. Countries with relatively lower costs of sterilization, possibly due to greater tolerance to domestic financial system distortion, might accumulate ever-increasing amounts of international reserves, emerging as short run winners in the reserve hoarding game. This seems to be the reality in several Asian economies (China being the glaring example). However, one must be careful while weighting the short-run benefits of reserve accumulation against its short and long run costs and examine the likelihood of costs overshadowing the benefits over time. We use the term sterilization in a restrictive sense: capturing open market operations conducted in order to absorb excess liquidity resulting from foreign reserve accumulation.

2.5 Model

2.5.1 Basic Framework

In this and the following section, we describe our benchmark small open economy framework. Some of its features are borrowed from models of credit constraints with a housing sector, pioneered by Kiyotaki and Moore (1997) and Iacoviello (2005). We use a few key ingredients from their original framework, simplified to suit our research inquiry. In addition, we introduce the sterilization dimension where the government sector accumulates foreign reserves and also conducts open market operations in response to the foreign reserve inflows.There is no central bank and therefore no explicit role for monetary policy in our model.[21] We recast the housing asset (H) as a government bond, which is an open market instrument held by the households and used as collateral.

as to facilitate the interpretation of the sterilization coefficient (β) as follows: β = -1 (complete sterilization) $\beta = 0$ (No sterilization), β between -1 and 0 (partial sterilization).

[21]Since we use a 'real' model, we need to interpret the term sterilization in a narrow sense: linking reserve accumulation policy with sale of government securities.

The economy consists of two agents: Households (private agents) and the Government. It does not seem necessary to explicitly introduce the firm as another optimizing entity so we use the aggregate production function and capital accumulation equation as a reduced form description of economy-wide production activity.

Households are assumed to be credit-constrained. They engage in private borrowing as well as hold a one-period bond issued by the domestic government. The extent of their private borrowing is limited by the collateralized value of their total bond wealth. In other words, government acts as the super-intermediary in our model. Its critical role is to mitigate the imperfections caused by domestic financial market inefficiency.[22]

The reason we need both private borrowing and bonds (akin to government securities in open market operations) is because one constitutes an asset and the other serves as a collateral to help relax the domestic credit constraint. In essence, households supply labor and capital for production purposes, borrow privately, hold government bonds, pay taxes (net of transfers) to the government and use the income for consumption, investment, tax payment and increasing their asset holdings/borrowing. Why should the private agents be motivated to hold low-yielding government securities? The answer can be linked to the role of government bonds in relaxing the household's borrowing constraint.

An important assumption we make is that the representative household is impatient (has a lower discount factor and thus discounts the future heavily.) Moreover, the small open economy is characterized by an inefficiently low level of capital and output. In a frictionless world with no market inefficiencies, marginal product of capital would be identical to the intertemporal marginal rate of substitution governed

[22]This is a critical assumption in the model, as it implicitly restricts several avenues of foreign investment such as foreign direct investment (FDI), foreign institutional investment (FII) etc. Domestic agents cannot borrow indefinitely and foreign investors cannot engage in unfettered investment in domestic financial assets. This is indicative of inefficiency in domestic financial markets.

by the household's rate of time preference. With relatively scarce capital stock, this would imply that the economy in question receives foreign capital (inflows). However, this runs contrary to the evidence of uphill foreign capital flows. Therefore, it must be the case that financial market inefficiencies (caused by relatively underdeveloped financial system) create a wedge between the marginal product of domestic capital stock (MPK) and the world interest rate (R).

Each period, the domestic government raises funds by levying taxes and issues securities to households via open market operations. The total revenue generated is used to accumulate foreign exchange reserves and paying off last period's debt. We further assume that the primary motive for holding international reserves is their role as sovereign collateral (buffer stock protecting against unforeseen phenomena such as sudden stops). Reserve accumulation, in turn, relaxes the household's credit constraint, putting downward pressure on the domestic interest rate.

One can envision the government in this economy running a warehouse of reserves. Government bonds serve as warehouse certificates/coupons, and households hold these certificates which serve as indirect claims on international reserves.[23] We now translate the basic tenets of our story into the system of equations governing the benchmark model.

[23]This is analogous to thinking about gold being the only form of reserve that can be held. In this case, no one would like to risk keeping gold in their house. Therefore, government would act as the custodian of gold and issue claims based on specific value of gold, which in turn would be held by the households.

2.5.2 The Benchmark Model

Household (Private Agent)

The representative household maximizes the period utility function given below.

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t [lnC_t - \frac{{L_t}^{\eta}}{\eta}] \tag{2.5.1}$$

where $\beta \in (0, 1)$ is the time discount factor and η is a measure of labor supply elasticity.

Subject to the following inter-temporal budget constraint:

$$w_t L_t + r_t K_t + Q_t H_t + B_t \geq C_t + I_t + T_t + H_{t+1} + RB_{t-1} \tag{2.5.2}$$

w_t: Wage rate

r_t: Rental rate

Q_t: Yield (interest rate paid) on the government bond

H_t: One period government bond

B_t: Private borrowing by the household in the international market

C_t: Consumption

I_t: Investment spending

T_t: Federal Taxes (net of transfer payments)

R: World Interest rate (cost of private borrowing)

In addition, the households are faced with a borrowing (credit) constraint such that their bond holdings are limited by a fraction of the aggregate bond equity they possess since the one period bond is used as a collateral.

$$B_t \leq \gamma_H H_t \tag{2.5.3}$$

Where γ_h reflects the fraction of bond equity pledged as collateral. A higher value of γ_H helps relax the household's credit constraint. Thus γ_H serves as a reduced form way of capturing the degree of financial market development.

Government

The budget constraint of government can be described by the following identity equating the sources and uses of funds.

$$H_{t+1} + T_t + X_{t-1} = Q_t H_t + X_t \tag{2.5.4}$$

The sources of funds consist of net tax revenue (T_t), newly issued bonds during the current period (H_{t+1}) and foreign reserves from the last period (X_{t-1}). The uses of funds are debt repayment for the last period ($Q_t H_t$) as well as newly accumulated foreign reserves (X_t).[24]

Rearranging the terms yields the following government budget constraint:

$$H_{t+1} + T_t = (X_t - X_{t-1}) + Q_t H_t \tag{2.5.5}$$

In addition, we use the following equation to establish the association between government bonds (open market sales) and international reserve accumulation.

$$H_t = \gamma_X X_t \tag{2.5.6}$$

Bond issuance must be backed by an adequate amount of international reserves (collateral), to protect the government's credibility in the event of a financial panic or crisis of confidence.

[24]We assume that price of the one-period bond today is one dollar and it pays Q_t (rate of return) in the next period.

Combining the household's borrowing constraint with the equation linking open market operation (bond issuance) and reserve accumulation yields:

$$B_t = \gamma_H \gamma_X X_t \tag{2.5.7}$$

The above equation encapsulates two critical dimensions. 1. How many units of bonds H_t does the government issue for each dollar of foreign reserves held (γ_x) 2. How well does H_t serve as collateral to facilitate private borrowing by relaxing household's credit constraint? In addition, this equation shows that governments can potentially compensate for lower efficiency of the domestic financial system (captured by smaller values of either or both of the γ parameters) by accumulating more foreign reserves.

The aggregate production function in the economy is given by:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{2.5.8}$$

where A_t denotes total factor productivity and α is the share of capital in production.

The law of motion for the total capital stock is given by:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{2.5.9}$$

The aggregate budget constraint for the economy is derived by integrating the period budget constraints for households and the government, assuming that they hold with equality in equilibrium. Therefore we have:

$$w_t L_t + r_t K_t + Q_t H_t + B_t + H_{t+1} + T_t = C_t + I_t + T_t + H_{t+1} + RB_{t-1} + (X_t - X_{t-1}) + Q_t H_t \tag{2.5.10}$$

Canceling common terms on both sides leads to the following national income ac-

counting identity in our benchmark small open economy model:

$$Y_t \equiv w_t L_t + r_t K_t = C_t + I_t + (RB_{t-1} - B_t) + (X_t - X_{t-1}) \tag{2.5.11}$$

Total factor income is thus equal to the sum of domestic spending (consumption + investment), net private borrowings, and foreign reserve accumulation.[25]

To begin with, we solve the model and derive the following optimality conditions with respect to C_t, L_t, K_{t+1}, H_{t+1}, and B_t.

$$\frac{1}{C_t} = \lambda_t \tag{2.5.15}$$

$$L_t^{\eta-1} = \frac{w_t}{C_t} \tag{2.5.16}$$

$$\frac{1}{C_t} = \beta E_t[\frac{1}{C_{t+1}}(r_{t+1} + 1 - \delta)] \tag{2.5.17}$$

$$\frac{1}{C_t} - \beta E_t \frac{1}{C_{t+1}} Q_{t+1} = \beta \gamma_H E_t \mu_{t+1} \tag{2.5.18}$$

The left hand side of the above equation represents the user cost of bond holding in terms of marginal utility of consumption.

$$\frac{1}{C_t} - \beta R E_t \frac{1}{C_{t+1}} = \mu_t \tag{2.5.19}$$

Equations 2.5.15 and 2.5.16 represent the standard optimality conditions with

[25] Using the production function, we can derive the optimality conditions with respect to labor and capital.

$$w_t = (1-\alpha)[Y_t/L_t] \tag{2.5.12}$$

$$r_t = \alpha[Y_t/K_t] \tag{2.5.13}$$

Therefore total factor payments (wages and rental income) exhaust the aggregate output, satisfying the Euler Theorem.

$$w_t L_t + r_t K_t = (1-\alpha)[Y_t/L_t] * L_t + \alpha[Y_t/K_t] * K_t = (1-\alpha)Y_t + \alpha Y_t = Y_t \tag{2.5.14}$$

respect to C_t (equating marginal utility of consumption with the shadow value of household's budget constraint) and L_t (labor-leisure trade-off). First order condition with respect K_{t+1} yields the Euler equation 2.5.17. First order condition with respect to H_t (eq. 2.5.18) links the user cost of owning a bond for one period with the shadow value of the credit constraint, where λ_t and μ_t are the shadow values associated with the household's budget constraint and the credit constraint, respectively. Finally, equation 2.5.19 establishes the link between the two multipliers, rate of time preference, and the world interest rate.

From the production function, we get the following factor market equilibrium conditions for labor L_t and capital K_t.

$$w_t = (1 - \alpha)[Y_t/L_t] \tag{2.5.20}$$

$$r_t = \alpha[Y_t/K_t] \tag{2.5.21}$$

Next, we calculate the steady state of our benchmark model.[26] We can then use numerical experiments and comparative static exercises to understand how specific combinations of structural parameters (governing institutional environment and financial development) are consistent with the policy of substantial reserve accumulation.(A pattern observed in several emerging countries most notably emerging Asia and Latin America.)[27]

[26]The subscript 's' denotes the steady state value of a given variable.

[27]Detailed derivations of the first order conditions as well as the steady state solutions are presented in the appendix.

2.5.3 Steady State

The steady state capital-output, labor-output, and capital-labor ratios as well as the steady state values of output, consumption, capital, investment and labor are calculated using the expressions derived below.

$$\frac{Y_s}{K_s} = [\frac{1-\beta+\beta\delta}{\alpha\beta}] \tag{2.5.22}$$

$$\frac{K_s}{L_s} = [\frac{Y_s}{K_s}]^{\frac{1}{\alpha-1}} = [\frac{1-\beta+\beta\delta]}{\alpha\beta}]^{\frac{1}{\alpha-1}} \tag{2.5.23}$$

$$\frac{Y_s}{L_s} = [\frac{1-\beta+\beta\delta}{\alpha\beta}]^{\frac{\alpha}{\alpha-1}} \tag{2.5.24}$$

$$w_s = (1-\alpha)[\frac{1-\beta+\beta\delta}{\alpha\beta}]^{\frac{\alpha}{\alpha-1}} \tag{2.5.25}$$

$$r_s = \alpha[\frac{1-\beta+\beta\delta}{\alpha\beta}] = [\frac{1-\beta+\beta\delta}{\beta}] \tag{2.5.26}$$

$$R < \frac{1}{\beta} = (r+1-\delta) \tag{2.5.27}$$

$$C_s = \frac{1}{\lambda_s} \tag{2.5.28}$$

$$(1-\beta R)\lambda_s = \mu_s \tag{2.5.29}$$

$$Q_s = \frac{1}{\beta}[1 - \frac{\beta\mu_s\gamma_H}{\lambda_s}] \tag{2.5.30}$$

$$Y_s = (1-\alpha)^{\frac{1}{\eta-1}}(\lambda_s)^{\frac{1}{\eta-1}}[\frac{Y_s}{L_s}]^{\frac{\eta}{\eta-1}} \tag{2.5.31}$$

$$K_s = [\frac{K_s}{Y_s}]Y_s = [\frac{\alpha\beta}{1-\beta+\beta\delta}]Y_s \tag{2.5.32}$$

$$L_s = [(1-\alpha)\lambda_s Y_s]^{\frac{1}{\eta}} = (w\lambda_s)^{\frac{1}{\eta-1}} \tag{2.5.33}$$

$$I_s = \delta K_s \tag{2.5.34}$$

Combining the household's borrowing constraint with the relationship between government bonds and foreign reserves we have:

$$B_s = \gamma_H H_s \tag{2.5.35}$$

$$H_s = \gamma_X X_s \tag{2.5.36}$$

Therefore: $B_s = \gamma_H \gamma_X X_s$.

We have assumed that $\beta < 1/R$. Therefore, equation 2.5.19 in steady state implies that $\mu > 0$ meaning that the households are faced with a binding borrowing constraint (using the complimentary slackness theorem).

Note that the aggregate resource constraint in the steady state is given by:[28]

$$Y_s = C_s + I_s + (R-1)B_s = C_s + \delta K_s + (R-1)B_s \tag{2.5.37}$$

Substituting the value of K_s in terms of Y_s and plugging in the steady state expressions for C_s, B_s we have:

$$Y_s[1 - \delta \frac{K_s}{Y_s}] = \frac{1}{\lambda_s} + (R-1)\gamma_H \gamma_X X_s \tag{2.5.38}$$

Our main objective is to calculate the numerical steady state of the benchmark model before proceeding to the comparative static experiments using various combinations of structural parameters (γ_H, γ_X) and reserve policy choice X. We pick standard parameter $\alpha = 0.3$, $\beta = 0.99$, $\delta = 0.05$ and $\eta = 4$ to compute the steady

[28]There is no net reserve accumulation in the steady state since $X_t = X_{t-1}$. Nevertheless, government uses X as a policy instrument. By choosing to accumulate a higher quantity of reserves (choosing a large value for X), government can partially compensate for domestic financial inefficiency (lower value of γ_H). In addition, based on our assumption of household impatience; steady state in our model is associated with positive level of borrowing. In other words, in equilibrium, the country as a whole borrows (B_s) and thereafter pays interest rate R in perpetuity. However, the economy would not prefer to borrow once the marginal products of capital are equalized $R = r+1-\delta$, as additional debt would entail a net loss.

state labor-output and capital-output ratios (expressed in terms of the model parameters). Supplementing these with the choice of gross interest rate $R = 1.005$, financial and institutional measures $\gamma_H = 0.5$, $\gamma_X = 0.5$, and policy choice $X = 10$ (Reserves to GDP ratio) as well as the steady state value of output (Y_s), the above equation can be solved to pin down the value of λ_s (one equation in one unknown). In turn, we can substitute the resulting value of λ_s back into the above steady state expressions 2.5.28 to 2.5.34 to calculate C_s, μ_s, Q_s, Y_s, K_s, I_s and L_s respectively.[Stepwise details of the calculations are presented in the appendix.]

Note (from equation 2.5.38) that the value of λ_s depends critically on the expression for B_s, given by the product of the two structural parameters (γ_H and γ_X) as well as the choice of X (reserve policy). Other things equal, a higher value of γ_H (improvement in financial efficiency) or γ_X (bond - reserve link) or X (choice of reserve holdings) increases the corresponding value of λ. Interestingly enough, due to the multiplicative nature of the term $\gamma_H \gamma_X X$, a variety of combinations are simultaneously consistent with a single value of λ_s. This helps us focus on a wide range of structural parameters, while still keeping track of a relatively limited set of λ values.

We create a granular grid for γ_H and γ_X. Specifically, we consider values of γ_H and γ_X ranging from numbers close to zero (0.001) to scalars greater than equal to one (up to 5 and 10 respectively). In addition, we examine three distinct choices of X namely; 2(low), 10(average) and 40(high).[29] Based on the three distinct reserve policy rules and the structural parameter-mix, corresponding series of λ_s are derived and in turn, used to calculate the new steady state values of Y_s and C_s.[30]

A few comparative static results emerging from our numerical experiments warrant attention. To begin with, based on the steady state expressions outlined earlier,

[29]Consider X to be analogous to the reserves to GDP ratio in a country.

[30]Note that since the capital-output and labor-output ratios are constant in the steady state and only depend on the model parameters, dynamics of K_s, I_s and L_s mimic the behavior of Y_s and so need not be analyzed separately.

it is clear that output and consumption are positively and negatively related to the value of λ_s respectively. Alternatively, as λ_s rises, so do the steady state values of Y_s, K_s, I_s and L_s but on the other hand, C_s falls commensurately. Given the steady state expression for the aggregate resource constraint, the rise in output is driven by domestic investment (and private borrowing) as consumption is dampened. These dynamics (specifically the output growth) are considerably magnified when we transition from low to high reserve accumulation. Moreover, in the high-reserve scenario (high X), output rises considerably even for considerably lower values of γ_H (financial inefficiency). In addition, the quantitative impact on output and consumption becomes more distinguishable and conspicuous as λ becomes considerable large (values greater than 0.7).[31] Table 2.4 in the appendix summarizes the main results of our comparative statics exercise based on select combinations of γ_H and γ_X as well as three distinct reserve policy choices.

2.6 Concluding Remarks

This paper explores the relationship between institutional quality, financial development and reserve accumulation in emerging and developing countries, both from an empirical and theoretical perspective. Partition-based cluster analysis is used to capture structural heterogeneities within our sample and identify stylized facts with regards to foreign reserve dynamics. The cluster outputs indicate the overarching importance of financial, institutional, and economic variables (going beyond just geographic separation) to isolate groups of relatively similar countries. Most notably, the cluster memberships indicate that BRIC countries, newly industrialized Asian giants, and select Latin American economies occupy the top rung of the reserve ladder. On

[31] Interestingly enough, several combinations of structural parameters and reserve policy choice are consistent with a very narrow band of λ ranging from 0.6807 to 0.6985.

the contrary, more than sixty percent of our sample (countries in Central and Eastern Europe as well as most of the Latin American and African nations) is concentrated at the bottom end of the reserve hierarchy. These cluster compositions are quite robust, based on a battery of sensitivity tests.

In order to further investigate the role of underlying structural heterogeneities in explaining the reserve accumulation patterns, we undertake a rigorous statistical inquiry starting with the cross-section regression framework, and then gradually moving onto a more full-fledged panel data analysis. Income, institutions, openness and financial development have an important role in explaining cross-national variation in reserve accumulation. The panel data framework explores cluster-wise as well as regional heterogeneity by incorporating their interactions with select economic, institutional and financial measures. In addition, we are also able to explicitly control for global macroeconomic phenomena influencing the temporal evolution of foreign reserves.

Our results underscore the vital role played by key economic, institutional and financial variables in explaining the key patterns of reserve accumulation in the developing world. The most noteworthy observation is that the effects of these structural parameters vary considerably by cluster (relatively similar countries) and geography, not only in terms of their strength but also by direction. While the positive impact of income (measured by per capital GDP) and certain aspects of financial development (depth and efficiency of financial system) on reserves is fairly unanimous; the story behind institutional quality (legal, economic) and financial openness (Chinn–Ito Index) is more complicated and nuanced. Here, a wide range of cluster and region-specific coefficients exist, varying considerably in strength as well as sign.

In a nutshell, our investigation of foreign reserve dynamics in emerging and developing nations through the dual lens of cluster and regional grouping culminates

in several insightful observations at the same time leaving us with some intriguing puzzles, thus charting the path for future research.

The ongoing debate revolving around the opportunity cost of excessive foreign reserve holding coupled with fiscal and distortionary financial costs associated with sterilization has cast serious doubts about the long-term viability of sterilization as an efficient policy choice. As foreign capital inflows persist and emerging markets continue to amass foreign exchange reserves, singular reliance on sterilized intervention is not necessarily sustainable in the long run. Policymakers across the world continue to face the policy trilemma (the Impossible Trinity) involving exchange rate stability, monetary sovereignty, and free capital flows while promoting economic growth. As capital account liberalization deepens and gains momentum in the developing world, volatile foreign capital flows are bound to challenge the relatively underdeveloped and vulnerable domestic financial systems. The most pertinent policy prescription seems to warrant greater freedom and flexibility in policy choices coupled with strengthening the domestic financial architecture.

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2.7 Appendix

2.7.1 Derivation of the Optimality Conditions from the Baseline Model

We solve the household's optimization problem by setting up the Lagrangian, incorporating the period budget constraint as well as the borrowing constraint.

$\mathcal{L} = [\ln C_t - \frac{L_t}{\eta}^{\eta}] + \lambda_t[w_t L_t + r_t K_t + Q_t H_t + B_t - C_t - K_{t+1} + (1-\delta)K_t - H_{t+1} - RB_{t-1}] + \mu_t[\gamma_H H_t - B_t] + \beta E_t[lnC_{t+1} - \frac{L_{t+1}}{\eta}^{\eta}] + \beta E_t \lambda_{t+1}[w_{t+1}L_{t+1} + r_{t+1}K_{t+1} + Q_{t+1}H_{t+1} + B_{t+1} - C_{t+1} - K_{t+2} + (1-\delta)K_{t+1} - H_{t+2} - RB_t] + \beta E_t \mu_{t+1}[\gamma_H H_{t+1} - B_{t+1}] + ...$

Differentiating with respect to the decision variables C_t, L_t, K_{t+1}, H_{t+1},and B_t yield to the following five order conditions:

$$\frac{1}{C_t} = \lambda_t \tag{2.7.1}$$

$$-L_t^{\eta-1} + \lambda_t w_t = 0 \Rightarrow L_t^{\eta-1} = \frac{w_t}{C_t} \tag{2.7.2}$$

$$-\lambda_t + \beta E_t \lambda_{t+1}[r_{t+1} + (1-\delta)] = 0 \Rightarrow \frac{1}{C_t} = \beta E_t \frac{1}{C_{t+1}}[r_{t+1} + (1-\delta)] \tag{2.7.3}$$

$$-\lambda_t + \beta E_t \lambda_{t+1} Q_{t+1} + \beta \gamma_H E_t \mu_{t+1} \Rightarrow \frac{1}{C_t} - \beta E_t \frac{1}{C_{t+1}} Q_{t+1} = \beta \gamma_H E_t \mu_{t+1} \tag{2.7.4}$$

$$\lambda_t - \mu_t - \beta R E_t \lambda_{t+1} \Rightarrow \lambda_t - \mu_t = \beta R E_t \lambda_{t+1} \Rightarrow \frac{1}{C_t} + \beta R E_t \frac{1}{C_{t+1}} = \mu_t \tag{2.7.5}$$

2.7.2 Steady State Calculations

Using the Production Function $Y_t = A_t K_t^{1-\alpha} L_t^{\alpha}$ we can derive the expressions for $\frac{K_s}{L_s}$ and $\frac{Y_s}{L_s}$ as follows:

$$\frac{Y_s}{K_s} = K_s^{\alpha-1} L_s^{1-\alpha} \Rightarrow \frac{Y_s}{K_s} = [\frac{K_s}{L_s}]^{\alpha-1} = [\frac{1-\beta+\beta\delta}{\alpha\beta}] \tag{2.7.6}$$

Therefore:

$$\frac{K_s}{L_s} = [\frac{Y_s}{K_s}]^{\frac{1}{\alpha-1}} \tag{2.7.7}$$

$$\frac{Y_s}{L_s} = \frac{Y_s}{K_s} * \frac{K_s}{L_s} \Rightarrow [\frac{Y_s}{K_s}]^{\frac{\alpha}{\alpha-1}} = [\frac{1-\beta+\beta\delta}{\alpha\beta}]^{\frac{\alpha}{\alpha-1}} \tag{2.7.8}$$

Firm's optimality conditions imply the following expressions for factor prices:

$w_s = (1-\alpha)\frac{Y_s}{L_s}$; and $r_s = \alpha\frac{Y_s}{K_s}$

Plugging in the the expressions for $\frac{Y}{L}$ and $\frac{Y}{K}$ yields:

$$w_s = (1-\alpha)[\frac{1-\beta+\beta\delta}{\alpha\beta}]^{\frac{\alpha}{\alpha-1}} \tag{2.7.9}$$

$$r_s = \alpha[\frac{1-\beta+\beta\delta}{\alpha\beta}] = [\frac{1-\beta+\beta\delta}{\beta}] \tag{2.7.10}$$

The labor-leisure trade-off at the steady state implies:

$$L_s^{\eta} = (1-\alpha)\lambda Y_s \Rightarrow L_s = [(1-\alpha)\lambda Y_s]^{\frac{1}{\eta}} = (w\lambda)^{\frac{1}{\eta-1}} \tag{2.7.11}$$

We can use the above expressions for steady state labor supply, wage, and rental

rate to solve for the steady state value of output and capital.

$$\frac{1}{C_s} = \lambda \Rightarrow C_s = \frac{1}{\lambda_s} \tag{2.7.12}$$

$$\frac{1}{C_s} = \beta[\frac{1}{C_s}(r + 1 - \delta)] \Rightarrow \frac{1}{\beta} = (r + 1 - \delta) \tag{2.7.13}$$

We have assumed $R < \frac{1}{\beta}$. Therefore we have, $R < \frac{1}{\beta} < (r + 1 - \delta)$

$$(\lambda_s - \mu_s) = \beta R \lambda_s \Rightarrow \beta R = \frac{\lambda_s - \mu_s}{\lambda_s} < 1 \Rightarrow \lambda_s - \mu_s < \lambda_s \Rightarrow \mu_s > 0 \tag{2.7.14}$$

$$\lambda_s - \beta\lambda_s Q_s = \beta\mu_s\gamma_H \Rightarrow Q_s = \frac{\lambda_s - \beta\mu_s\gamma_H}{\beta\lambda_s} = \frac{1}{\beta}[1 - \frac{\beta\mu_s\gamma_H}{\lambda_s}] \tag{2.7.15}$$

For reasonable parameter values of (β, λ, μ, and γ_H); the above inequality implies that $Q < \frac{1}{\beta}$.

$$\beta(r + 1 - \delta) = 1 \Rightarrow \alpha\frac{Y_s}{K_s} + 1 - \delta = \frac{1}{\beta} \Rightarrow \frac{Y_s}{K_s} = [\frac{1 - \beta + \beta\delta]}{\alpha\beta}] \tag{2.7.16}$$

$$Y_s = \frac{L_s^\eta}{(1-\alpha)\lambda_s} = \frac{(w_s\lambda)^{\frac{\eta}{\eta-1}}}{(1-\alpha)\lambda_s} = \frac{[(1-\alpha)\frac{Y_s}{L_s}\lambda_s]^{\frac{\eta}{\eta-1}}}{(1-\alpha)\lambda_s} \tag{2.7.17}$$

Therefore:

$$Y_s = (1-\alpha)^{\frac{1}{\eta-1}}\lambda_s^{\frac{1}{\eta-1}}[\frac{1 - \beta + \beta\delta}{\alpha\beta}]^{\frac{\alpha\eta}{(\alpha-1)(\eta-1)}} \tag{2.7.18}$$

And using the steady state value of output Y_s we get:

$$L_s = [(1-\alpha)\lambda_s Y_s]^{\frac{1}{\eta}} = (w_s\lambda_s)^{\frac{1}{\eta-1}} \tag{2.7.19}$$

$$K_s = [\frac{\alpha\beta}{1-\beta+\beta\delta}]Y_s \tag{2.7.20}$$

The law of motion for capital stock reduces to the following expression for steady state investment:

$$I_s = \delta K_s \tag{2.7.21}$$

2.7.3 Numerical Steady State and Comparative Statics

As a reference point for our steady state calculations, we begin with the following values of model parameters and reserve policy choice:

$\alpha = 0.3$, $\beta = 0.99$, $\delta = 0.05$, $\eta = 4$

$R = 1.005$, $\gamma_H = 0.5$, $\gamma_X = 0.5$, $X = 10$

In order to arrive at the steady state value of λ_s, we focus on the steady state equivalent of the aggregate resource constraint and substitute the relevant steady state expressions. Therefore we have:

$$Y_s[1-\delta(\frac{\alpha\beta}{1-\beta+\beta\delta})] = \frac{1}{\lambda_s} + (R-1)\gamma_H\gamma_X X_s \tag{2.7.22}$$

Plugging in the benchmark parameter values results in the following equation.

$$1.67\lambda_s^{0.33} = \frac{1}{\lambda_s} + 0.0125 \tag{2.7.23}$$

Solving the above equation yields $\lambda_s = 0.6851$. Now, we go back the steady state expressions derived earlier and calculate their numerical values based on this specific value of λ_s.

$\lambda_s = 0.6851$, $\mu_s = (1-\beta R)\lambda_s = 0.0035$

Important steady state ratios are calculated as follows:

$\frac{Y_s}{K_s} = 0.2003$

$\frac{K_s}{L_s} = 9.9449$

$\frac{Y_s}{L_s} = 1.9920$

Steady state values for factor prices (wages and rental rate) are:

$w_s = (1-\alpha)\frac{Y_s}{L_s} = 1.3944$, $r_s = \alpha\frac{Y_s}{K_s} = 0.0601$

Finally, steady state levels of key variables are computed as below:

$C_s = 1/\lambda_s = 1.4597$

$Y_s = (1-\alpha)^{\frac{1}{\eta-1}}(\lambda_s)^{\frac{1}{\eta-1}}[\frac{Y_s}{L_s}]^{\frac{\eta}{\eta-1}} = 1.9618$

$K_s = [\frac{\alpha\beta}{1-\beta+\beta\delta}]Y_s = 9.7944$

$I_s = \delta K_s = 0.4897$

$L_s = (w_s\lambda_s)^{\frac{1}{\eta-1}} = 0.9849$

Table 2.4: Comparative Statics under Different Reserve Choices

X = 2	γ_h	γ_x	λ	Y_2	C_2	I_2
	0.001	0.001	0.6807	1.95743	1.46908	0.48862
	1	1	0.6842	1.96078	1.46156	0.48946
	1	5	0.6985	1.97435	1.43164	0.49285
	1	10	0.717	1.99162	1.3947	0.49716
	5	5	0.7777	2.0463	1.28584	0.51081
	5	10	0.8993	2.14782	1.11198	0.53615

X = 10	γ_h	γ_x	λ	Y_10	C_10	I_10
	0.001	0.5	0.6807	1.95743	1.46908	0.48862
	0.5	0.5	0.6851	1.96164	1.45964	0.48967
	0.5	10	0.7777	2.0463	1.28584	0.51081
	1	10	0.8993	2.14782	1.11198	0.53615
	5	5	1.5058	2.55042	0.6641	0.63665
	5	10	4.3649	3.63635	0.2291	0.90772

X = 40	γ_h	γ_x	λ	Y_40	C_40	I_40
	0.001	0.001	0.6807	1.95743	1.46908	0.48862
	0.5	1	0.717	1.99162	1.3947	0.49716
	0.5	5	0.8993	2.14782	1.11198	0.53615
	1	10	2.8084	3.13931	0.35607	0.78365
	5	5	27.4389	6.71073	0.03644	1.67517
	5	10	215.124	13.3305	0.00465	3.32764

Note: The first two columns in each of the panels represent different combinations of structural parameters γ_h and γ_x and the corresponding steady state value of λ. The remaining three columns trace the dynamics of output, consumption, and investment based on their steady state expressions derived earlier.

Country Sample , by Geography

ASIA		LATIN AMERICA		CENTRAL & EASTERN EUROPE		MIDDLE EAST & AFRICA	
Bangladesh	BN	Argentina	AR	Albania	AL	Egypt	EG
China	CH	Bolivia	BO	Armenia	AM	Jordan	JO
Hong Kong	HK	Brazil	BR	Belarus	BL	Morocco	MO
India	IN	Chile	CL	Bulgaria	BU	Nigeria	NG
Indonesia	IS	Colombia	CO	Latvia	LV	South Africa	SA
Malaysia	ML	Costa Rica	CR	Lithuania	LI		
Nepal	NP	Ecuador	EC	Poland	PO		
Pakistan	PK	El Salvador	EL	Romania	RO		
Phillipines	PH	Guatemala	GU	Russia	RU		
Thailand	TH	Mexico	MX	Turkey	TK		
Korea	KO	Panama	PN	Ukraine	UR		
Singapore	SG	Paraguay	PG				
Sri Lanka	SL	Peru	PR				
		Uruguay	UG				
		Venezuela	VZ				

Cluster Analysis - Snapshot 1					
1995-2010 [N=44]					
Cluster #	**1**	**2**	**3**	**4**	**5**
	AL	CH	AR	BR	IS
	AM		CL	HK	ML
	BL		CO	IN	MX
	BN		EG	KO	PO
	BO		MO	RS	TH
	BU		NG	SG	TK
	CR		PH		
	EC		PR		
	EL		RO		
	GU		SA		
	JO		UR		
	LI		VZ		
	LV				
	NP				
	PG				
	PK				
	PN				
	SL				
	UG				
Size	**19**	**1**	**12**	**6**	**6**

Variable Included in the Kmeans algorithm	
R	Foreign Reserves ($mn)
Ygr	Average annual GDP growth rate
CI	Chinn-Ito Index of financial openness

Cluster Analysis - Snapshot 2

(K = 4) 1995-2010

Cluster #	1	2	3	4
	AR	CH	BR	AM
	IS		IN	BN
	ML		KO	BO
	MX		RS	BU
	PO		SG	CL
	TH			CO
	TK			CR
				EC
				EG
				EL
				GU
				JO
				LI
				LV
				MO
				NG
				PG
				PH
				PK
				PN
				PR
				RO
				SA
				SL
				UG
				UR
				VZ
Size	**7**	**1**	**5**	**27**

(K = 5) 1995-2010

Cluster #	1	2	3	4	5
	BR	AM	CH	AR	IS
	IN	BN		CL	ML
	KO	BO		CO	MX
	RS	BU		EG	PO
	SG	CR		MO	TH
		EC		NG	TK
		EL		PH	
		GU		PR	
		JO		RO	
		LI		SA	
		LV		UR	
		PG		VZ	
		PK			
		PN			
		SL			
		UG			
Size	**5**	**16**	**1**	**12**	**6**

Variable Included in the Kmeans algorithm	
R	Foreign Reserves ($mn)
PCY	Per Capital GDP
Ygr	Average annual GDP growth (%)
Leg	Legal
Pol	Political
Eco	Economic
CI	Chinn-Ito Index of Financial Openness
PrCr	Private Credit to GDP Ratio(%)
NetInt	Net Interest Margin
BankZ	Bank Z score
StockCap	Stock market capitalization to GDP ratio(%)

Cluster Analysis by Five Year Time Windows - Snapshot 3

1995-2000 [N=37]				
#	1	2	3	4
	BR	AR	BN	CH
	IN	CO	BO	SG
	KO	EG	BU	
	ML	IS	CR	
	MX	PH	EC	
	TH	PO	EL	
		PR	GU	
		RS	JO	
		TK	LI	
			LV	
			MO	
			NG	
			PG	
			PK	
			PN	
			RO	
			SA	
			SL	
			UG	
			UR	
Size	6	9	20	2

2001-2005 [N=37]				
#	1	2	3	4
	CH	AR	BR	IN
		AM	IS	KO
		BN	ML	RS
		BO	MX	SG
		BU	PO	
		CO	TH	
		CR	TK	
		EC		
		EG		
		EL		
		JO		
		LI		
		LV		
		MO		
		NG		
		PK		
		PN		
		PG		
		PR		
		PH		
		RO		
		SA		
		SL		
		UR		
		UG		
Size	1	25	7	4

2006-2010 [N=38]				
#	1	2	3	4
	IS	CH	AR	BR
	ML		AM	IN
	MX		BN	KO
	PO		BO	RS
	TH		BU	SG
	TK		CL	
			CO	
			CR	
			EC	
			EG	
			EL	
			JO	
			LV	
			LI	
			MO	
			NG	
			PK	
			PN	
			PG	
			PR	
			PH	
			RO	
			SA	
			SL	
			UR	
			UG	
Size	6	1	26	5

Variable Included in the Kmeans algorithm	
R	Foreign Reserves ($mn)
PCY	Per Capital GDP
Ygr	Average annual GDP growth(%)
Leg	Legal
Pol	Political
Eco	Economic
CI	Chinn-Ito Index of Financial Openness
PrCr	Private Credit to GDP Ratio(%)
NetInt	Net Interest Margin
BankZ	Bank Z score
StockCap	Stock market capitalization to GDP ratio(%)

Cluster Analysis by Decades - Snapshot 4										
1990-2000 [N= 37]						2000-2010 [N=39]				
#	1	2	3	4		#	1	2	3	4
	CH	CR	AR	BN			AM	IS	BR	CH
	SG	LV	BR	BO			AR	ML	IN	
		LI	EG	BU			BN	MX	KO	
		PN	IN	CO			BO	PO	RS	
		SA	IS	EC			BU	TH	SG	
		UG	KO	EL			CL	TK		
			ML	GU			CO			
			MX	JO			CR			
			PO	MO			EC			
			RS	NG			EG			
			TH	PK			EL			
			TK	PG			JO			
				PR			LI			
				PH			LV			
				RO			MO			
				SL			NG			
				UR			PG			
							PH			
							PK			
							PN			
							PR			
							RO			
							SA			
							SL			
							UG			
							UR			
							VZ			
Size	**2**	**6**	**12**	**17**		**Size**	**27**	**6**	**5**	**1**

Variable Included in the Kmeans algorithm	
R	Foreign Reserves ($mn)
PCY	Per Capital GDP
Ygr	Average annual GDP growth (%)
Leg	Legal
Pol	Political
Eco	Economic
CI	Chinn-Ito Index of Financial Openness
PrCr	Private Credit to GDP Ratio(%)
NetInt	Net Interest Margin
BankZ	Bank Z score
StockCap	Stock market capitalization to GDP ratio(%)

Descriptive Statistics					
Variable	**N**	**Mean**	**Std. Dev.**	**Min**	**Max**
Institutional Quality					
Leg	43	-0.31	0.63	-1.21	1.31
Pol	42	-0.07	0.62	-1.21	0.98
Eco	42	-0.16	0.72	-1.47	1.80
Income and Growth					
PCY	44	4649.51	5699.54	290.98	27989.80
PCYgr	44	3.19	1.75	0.66	9.14
Ygr	44	4.33	1.50	1.51	9.93
Reserve Accumulation					
R	44	48212.79	125180.30	738.55	811339.00
RY	44	18.32	15.95	4.27	91.88
Financial Development					
CI	44	0.44	1.30	-1.33	2.44
PrCr	44	43.91	35.88	4.59	150.51
FinDep	44	44.20	37.89	4.64	229.66
NetInt	44	4.76	2.12	1.72	11.60
BankZ	44	15.03	11.32	-1.40	43.08
StockCap	42	46.26	66.59	0.64	355.24
StockTurn	42	42.31	55.74	0.96	220.10

Note:	**Variable Desctription**
Leg	Legal
Pol	Political
Eco	Economic
PCY	Per Capital GDP
PCYgr	Average annual Growth rate of GDP per capita
Ygr	Average annual GDP growth
R	Foreign Reserves ($mn)
RY	Reserves to GDP ratio (%)
CI	Chinn-Ito Index of Financial Openness
PrCr	Private Credit to GDP Ratio
FinDep	Financial System deposits to GDP ratio
NetInt	Net Interest Margin
BankZ	Bank Z score
StockCap	Stock market capitalization to GDP ratio
StockTurn	Stock markte turnover to GDP ratio

Reserves, Economic Growth & Financial Openness, Cluster-averages [1995-2010]					
Cluster #	**N**	**R**	**PCY**	**Ygr**	**CI**
1	**19**	2811.95	2789.15	4.43	0.87
2	**1**	811339.00	1731.56	9.93	-1.17
3	**12**	17257.54	3416.42	3.74	0.06
4	**6**	126682.10	13351.60	4.61	0.40
5	**6**	48235.62	4791.03	4.00	0.14

Cluster #	**N**	**R**	**PCY**	**Ygr**	**CI**
1	**7**	45205.43	5054.99	3.93	0.15
2	**1**	811339.00	1731.56	9.93	-1.17
3	**5**	125926.90	10635.78	4.82	-0.01
4	**27**	8501.24	3046.01	4.05	0.73

The top panel includes all the countries (44) but a smaller subset of variables (R,Ygr, CI). The bottom panel covers 40 countries and is based on a extended variable set covering reserves, income, growth, institutional quality, financial opneness, and financial development.

Note:	**Variable Desctription**
R	Foreign Reserves ($mn)
PCY	Per Capital GDP
Ygr	Average annual GDP growth
CI	Chinn-Ito Index of Financial Openness

Rank Correlation Matrix for Economic, Institutional and Financial Variables

	Leg	Pol	Eco	PCY	Ygr	CI	PrCr	FinDep	NetInt	BankZ	StCap	StTurn
Leg	1.00											
Pol	0.85	1.00										
Eco	0.70	0.73	1.00									
PCY	0.60	0.71	0.62	1.00								
Ygr	0.19	-0.08	0.12	-0.20	1.00							
CI	0.22	0.32	0.69	0.29	0.08	1.00						
PrCr	0.51	0.22	0.19	0.09	0.31	-0.11	1.00					
FinDep	0.43	0.17	0.13	0.06	0.35	-0.05	0.82	1.00				
NetInt	-0.42	-0.16	-0.13	-0.11	-0.52	0.00	-0.69	-0.65	1.00			
BankZ	0.20	0.11	0.23	-0.01	0.24	0.11	0.29	0.40	-0.13	1.00		
StCap	0.39	0.12	0.08	0.18	0.28	-0.23	0.63	0.63	-0.56	0.40	1.00	
StTurn	0.23	-0.08	-0.20	0.03	0.33	-0.51	0.38	0.48	-0.52	0.01	0.62	1.00

Note: Shaded cells denote statistically significant pairwise correlations.

Table 2.3a: Regional Heterogeneity I: Income and Reserve Accumulation

	Reserves(log)
Africa#PCGDP	1.42***
	(0.14)
Asia#PCGDP	1.17***
	(0.09)
CEE#PCGDP	1.12***
	(0.06)
LatAm#PCGDP	0.66***
	(0.09)
MENA#PCGDP	0.84***
	(0.16)
Time1: 1995-2000	0.44***
	(0.05)
Time2: 2001-2005	0.80***
	(0.05)
Time3: 2006-2010	1.09***
	(0.08)
Observations	869

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with per capita income (log). The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

Table 2.3b: Regional Heterogeneity II: Financial Openness and Reserve Accumulation

	Reserves(log)
Africa#FinOpen Index	0.49***
	(0.14)
Asia#FinOpen Index	0.19***
	(0.07)
CEE#FinOpen Index	0.27***
	(0.05)
LatAm#FinOpen Index	-0.05*
	(0.03)
MENA#FinOpen Index	-0.05
	(0.05)
Time1: 1995-2000	0.67***
	(0.05)
Time2: 2001-2005	1.21***
	(0.06)
Time3: 2006-2010	2.08***
	(0.06)
Observations	863

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with the Chinn Ito index (proxy for financial openness). The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

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Table 2.3c: Regional Heterogeneity III: Legal Institutions and Reserve Accumulation

	Reserves(log)
Africa#Inst-Legal	0.72***
	(0.22)
Asia#Inst-Legal	0.12
	(0.09)
CEE#Inst-Legal	-1.26***
	(0.19)
LatAm#Inst-Legal	0.46***
	(0.07)
MENA#Inst-Legal	-0.54**
	(0.24)
Time1: 1995-2000	0.73***
	(0.05)
Time2: 2001-2005	1.29***
	(0.06)
Time3: 2006-2010	2.20***
	(0.06)
Observations	807

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with quality of legal institutions in a country relative to others. The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

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Table 2.3d: Regional Heterogeneity IV: Economic Institutions and Reserve Accumulation

	Reserves(log)
Africa#Inst-Economic	0.76
	(0.49)
Asia#Inst-Economic	0.01
	(0.11)
CEE#Inst-Economic	0.90***
	(0.16)
LatAm#Inst-Economic	0.34***
	(0.06)
MENA#Inst-Economic	0.44**
	(0.17)
Time1: 1995-2000	0.68***
	(0.05)
Time2: 2001-2005	1.28***
	(0.06)
Time3: 2006-2010	2.16***
	(0.06)
Observations	805

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with quality of economic institutions in a country relative to others. The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

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Table 2.3e: Regional Heterogeneity V: Private Credit to GDP and Reserve Accumulation

	Reserves(log)
Africa#PrCr to GDP	1.10***
	(0.22)
Asia#PrCr to GDP	0.56***
	(0.12)
CEE#PrCr to GDP	0.52***
	(0.06)
LatAm#PrCr to GDP	0.06
	(0.09)
MENA#PrCr to GDP	-0.21
	(0.25)
Time1: 1995-2000	0.65***
	(0.06)
Time2: 2001-2005	1.17***
	(0.06)
Time3: 2006-2010	1.95***
	(0.06)
Observations	814

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with ratio of private credit to GDP (log). The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

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Table 2.3f: Regional Heterogeneity VI: Total Deposits to GDP and Reserve Accumulation

	Reserves(log)
Africa#Dep-GDP Ratio	1.13***
	(0.26)
Asia#Dep-GDP Ratio	1.09***
	(0.14)
CEE#Dep-GDP Ratio	1.10***
	(0.10)
LatAm#Dep-GDP Ratio	0.37***
	(0.10)
MENA#Dep-GDP Ratio	0.62
	(0.41)
Time1: 1995-2000	0.57***
	(0.05)
Time2: 2001-2005	0.98***
	(0.06)
Time3: 2006-2010	1.74***
	(0.06)
Observations	821

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with total financial system deposits to GDP ratio (log). The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

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Table 2.3g: Regional Heterogeneity VII: Stock Market Capitalization and Reserves

	Reserves(log)
Africa#StockCap-Y	0.86***
	(0.15)
Asia#StockCap-Y	0.37***
	(0.06)
CEE#StockCap-Y	0.20***
	(0.03)
LatAM#StockCap-Y	-0.04
	(0.05)
MENA#StockCap-Y	-0.03
	(0.07)
Time1: 1995-2000	0.60***
	(0.06)
Time2: 2001-2005	1.11***
	(0.07)
Time3: 2006-2010	1.90***
	(0.08)
Observations	698

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with the ratio of stock market capitalization to GDP (log). The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

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Table 2.3h: Regional Heterogeneity VIII: Stock Market Turnover and Reserves

	Reserves(log)
Africa#StockTurnover	0.41***
	(0.07)
Asia#StockTurnover	0.19***
	(0.05)
CEE#StockTurnover	-0.07
	(0.04)
LatAm#StockTurnover	0.14***
	(0.04)
MENA#StockTurnover	-0.10
	(0.08)
Time1: 1995-2000	0.63***
	(0.06)
Time2: 2001-2005	1.19***
	(0.06)
Time 3: 2006-2010	2.07***
	(0.06)
Observations	686

Standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variable is Reserves minus gold (log). The explanatory variables are interactions of five regional dummies with the stock market turnover ratio (log). The last three rows correspond to the time dummies for each of the five-year windows namely; 1995-2000, 2001-2005 and 2006-2010 to capture the impact of global macroeconomic events (common for the entire sample) on reserve accumulation.

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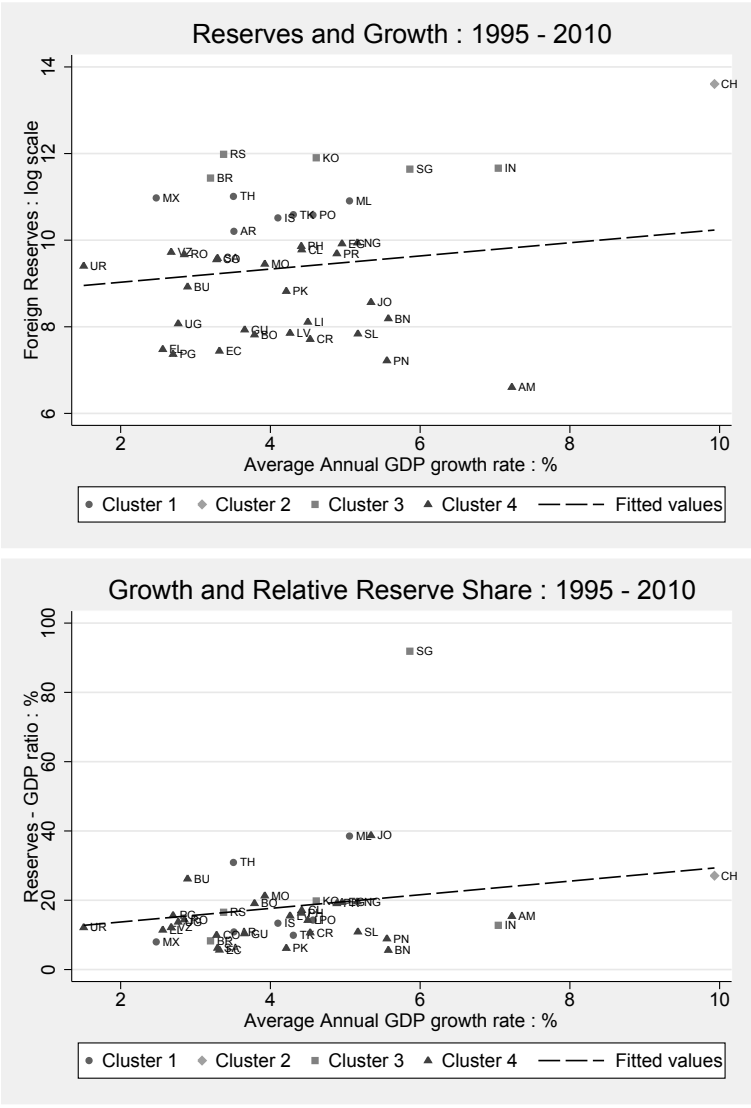


Figure 2.1a: Economic Growth and Reserve Accumulation: Full Sample

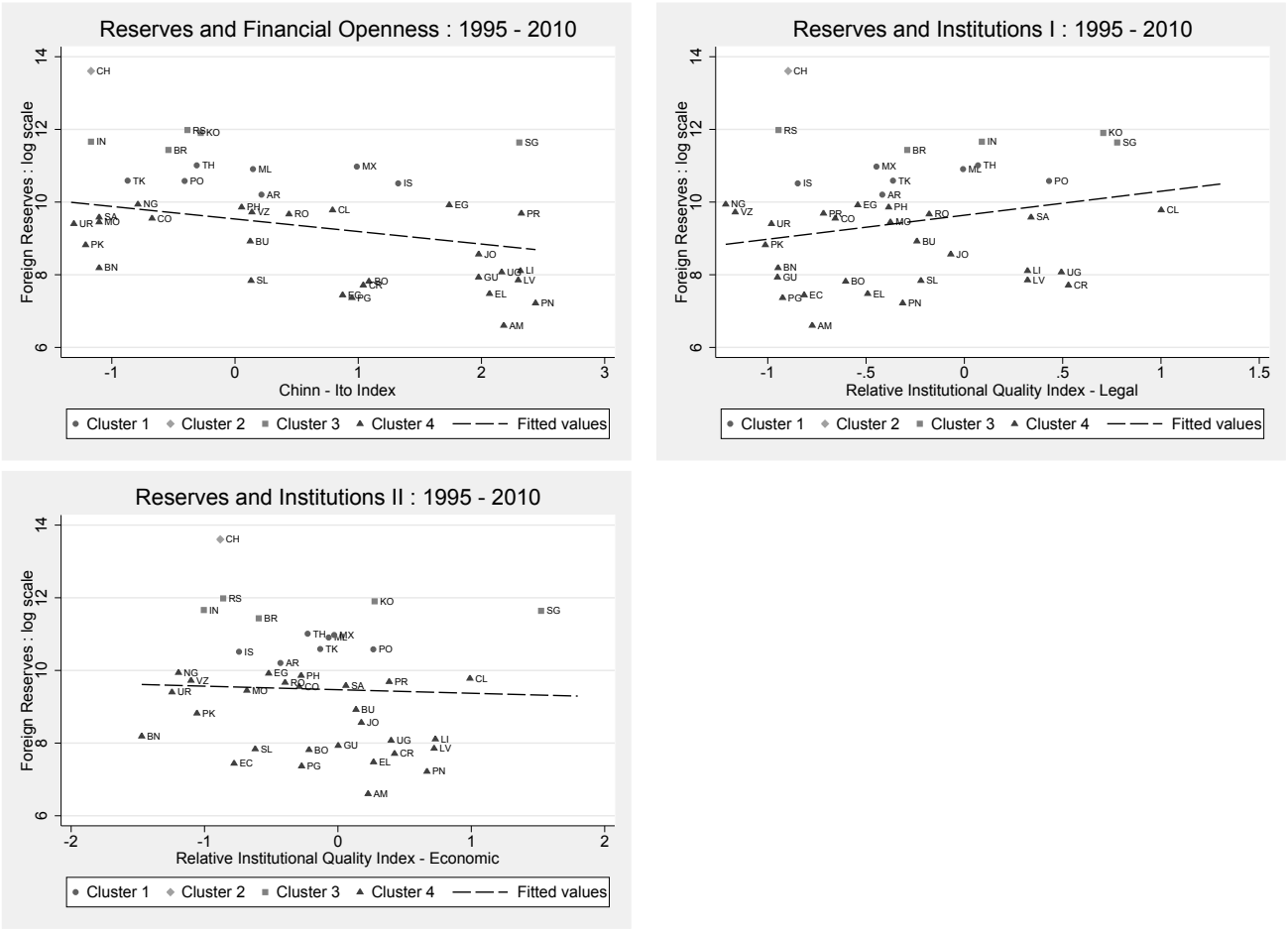


Figure 2.1b: Openness, Institutions and Reserve Accumulation: Full Sample

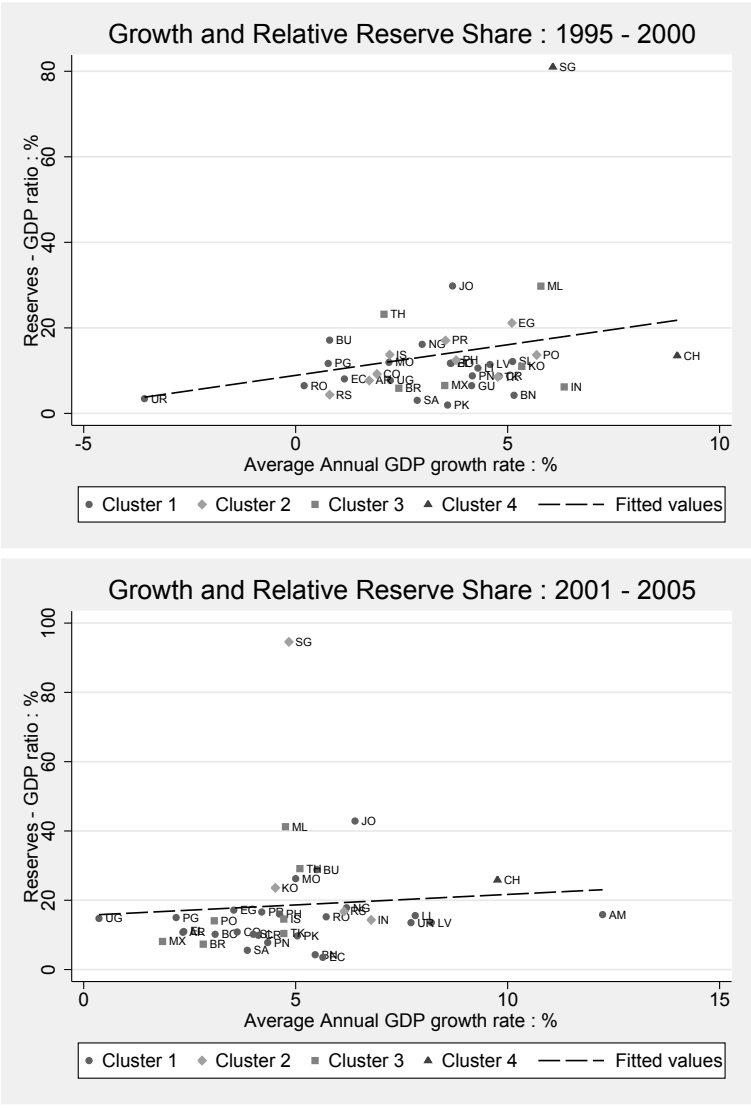


Figure 2.2a: GDP Growth and Relative Reserve Share: Five Year averages

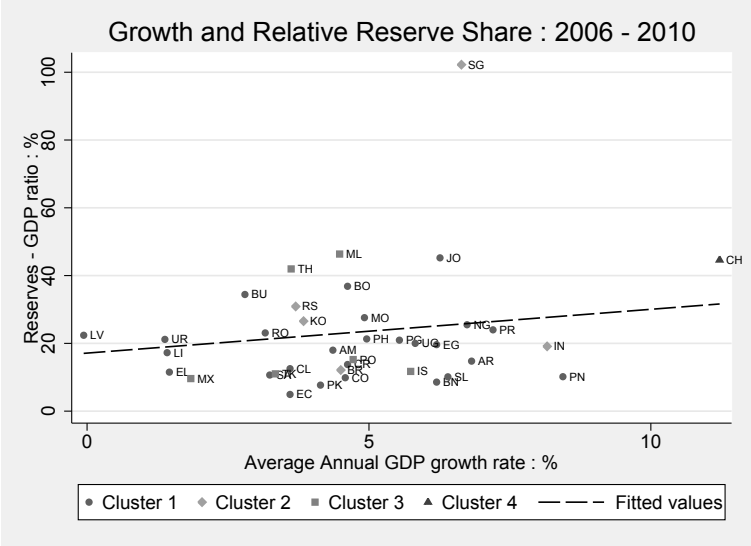


Figure 2.2b: GDP Growth and Relative Reserve Share: Five Year and Decade-averages

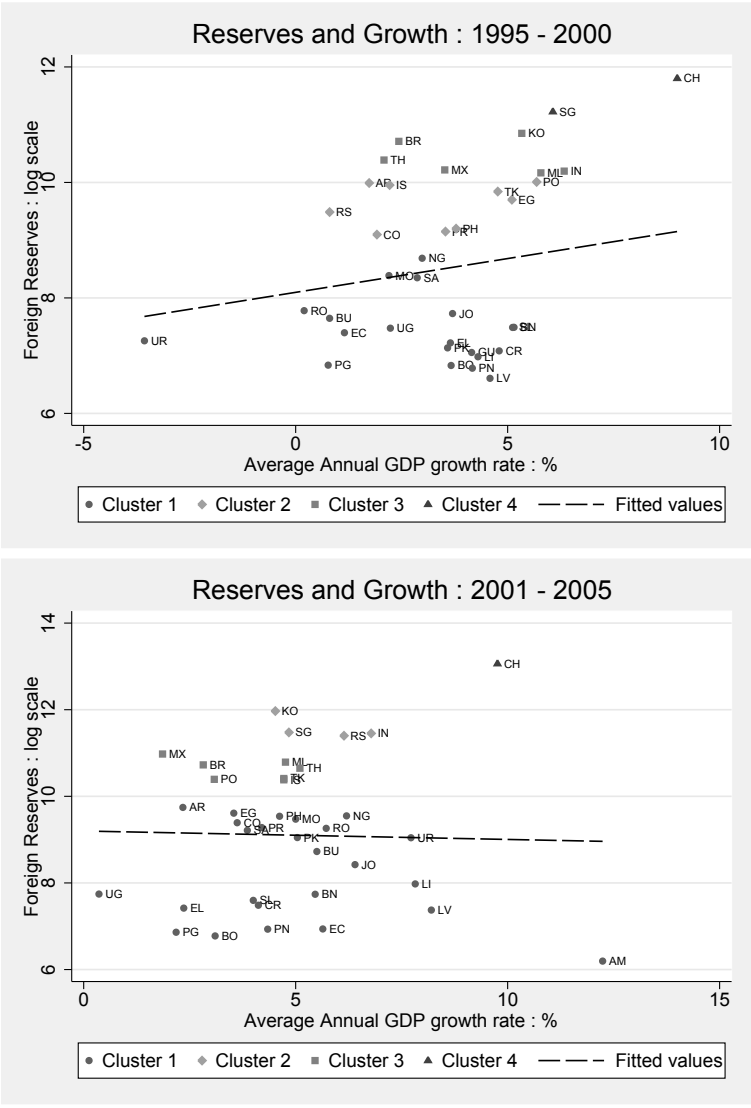
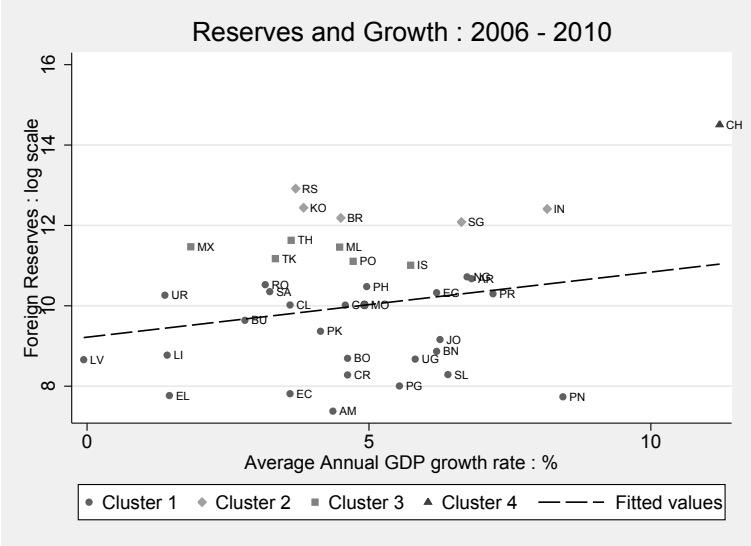


Figure 2.3a: GDP Growth and Reserve Accumulation: Five Year averages



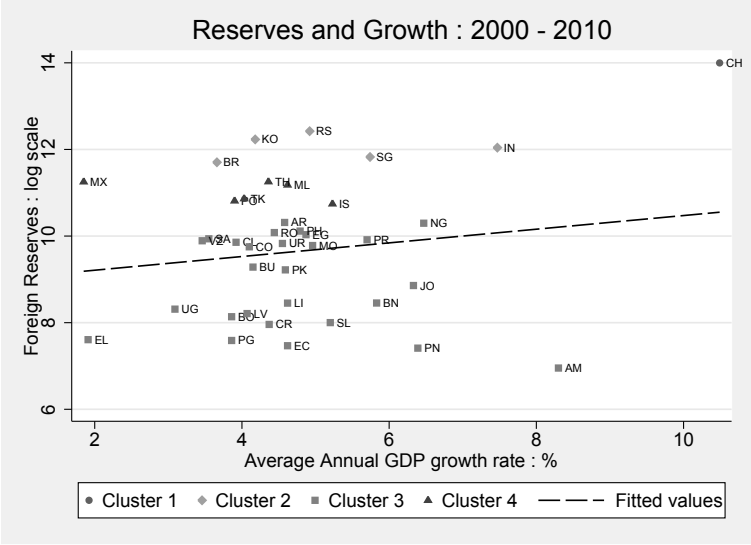


Figure 2.3b: GDP Growth and Reserve Accumulation: Five Year and Decade-averages

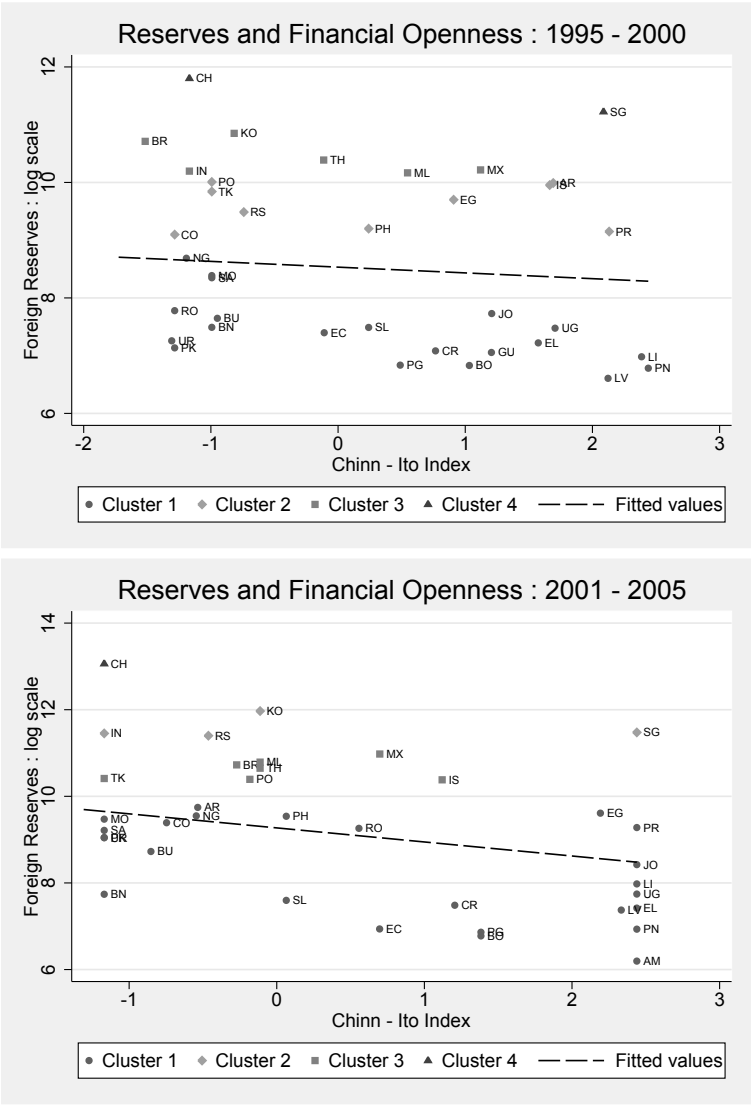
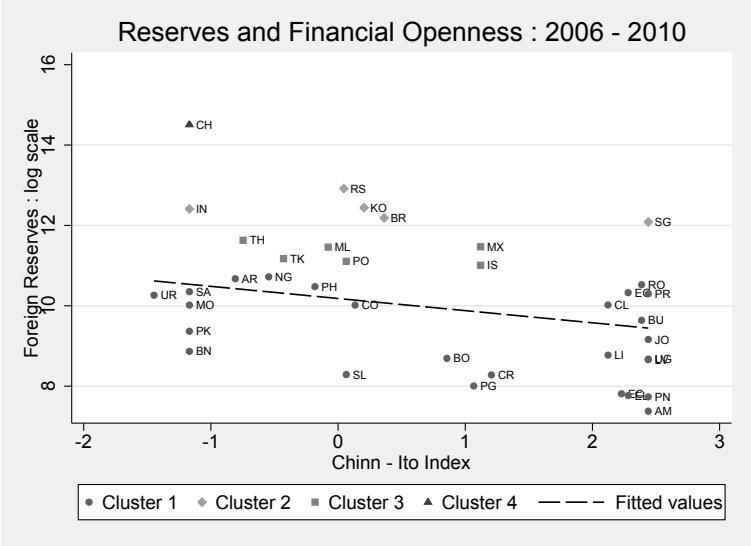


Figure 2.4a: Financial Openness and Reserve Accumulation: Five Year averages



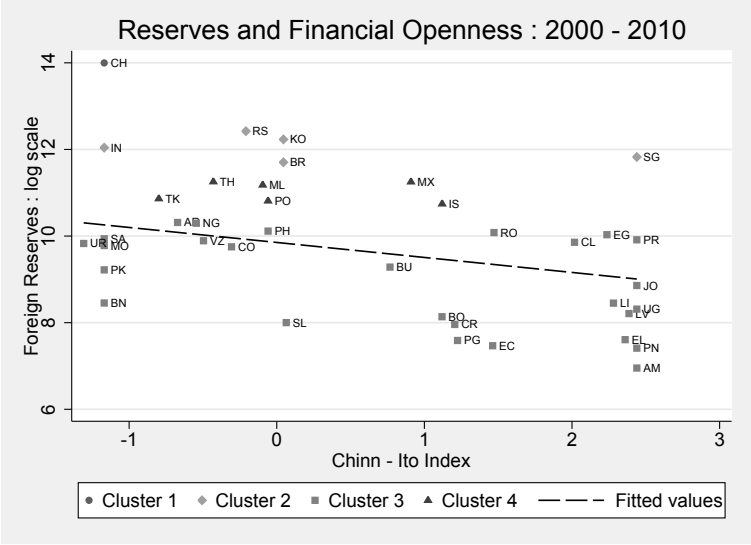


Figure 2.4b: Financial Openness and Reserve Accumulation: Five Year and Decade-averages

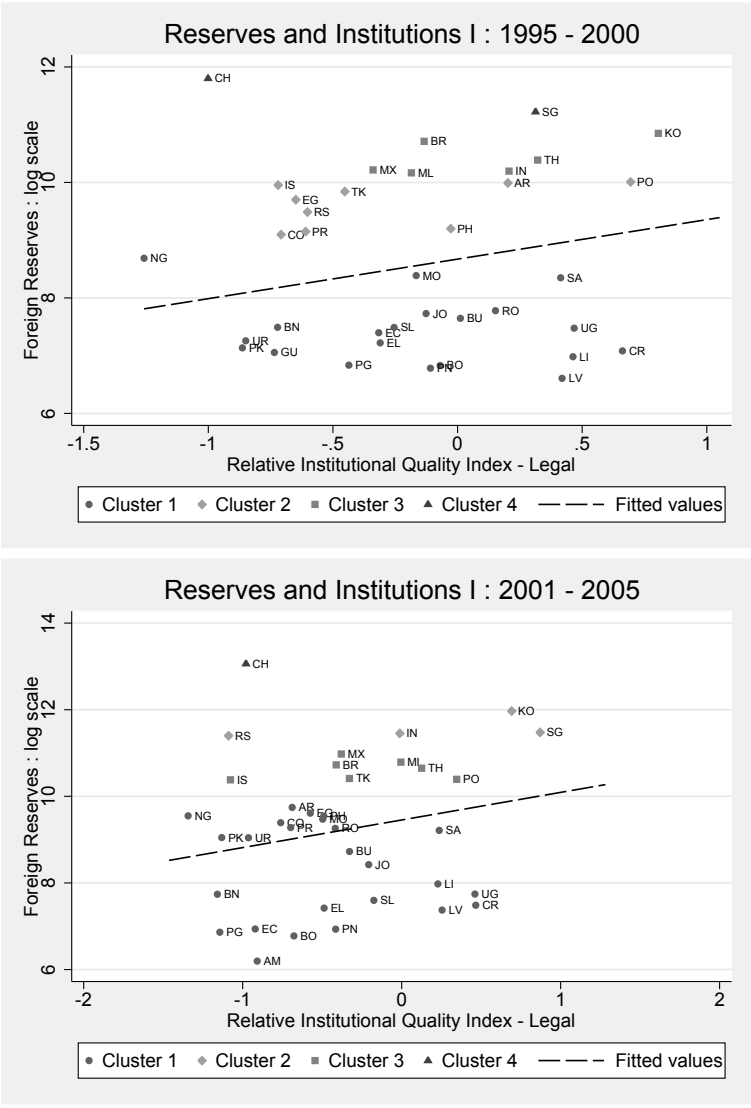
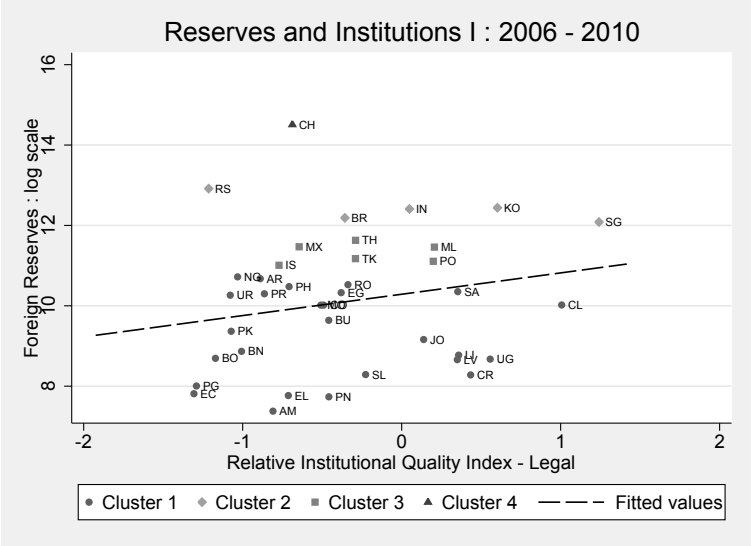


Figure 2.5a: Legal Institutions and Reserve Dynamics: Five Year averages



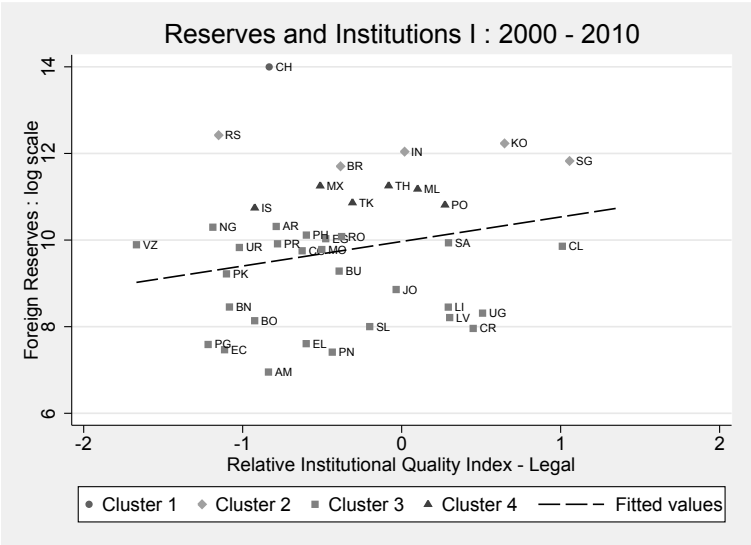


Figure 2.5b: Legal Institutions and Reserve Dynamics: Five Year and Decade-averages

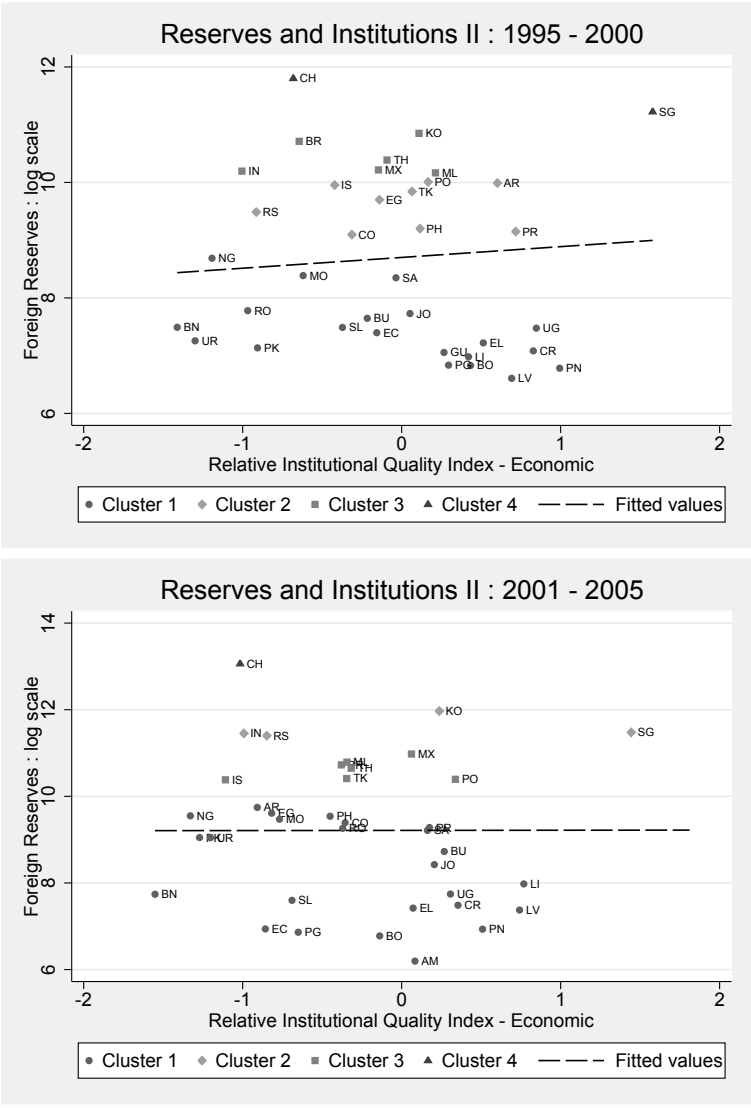


Figure 2.6a: Economic Institutions and Reserve Dynamics: Five Year averages

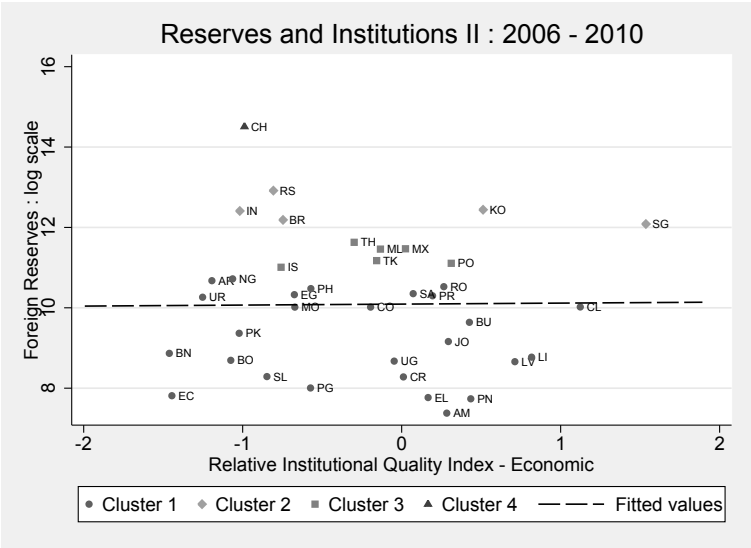


Figure 2.6b: Economic Institutions and Reserve Dynamics: Five Year and Decade-averages

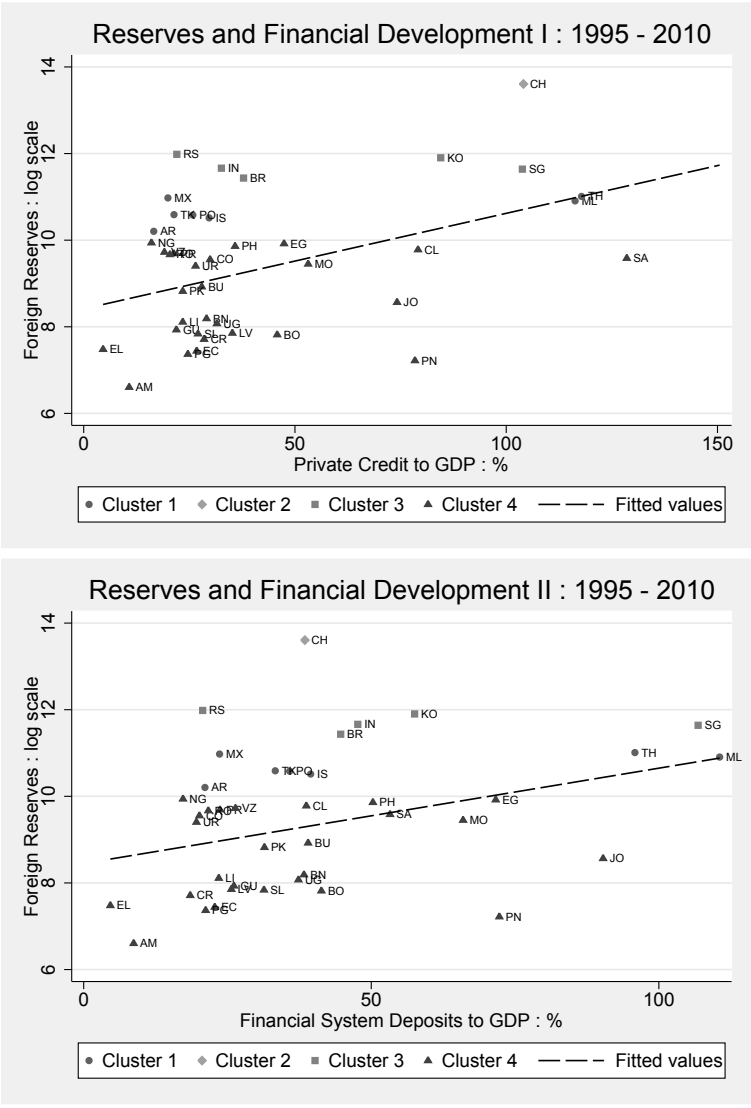


Figure 2.7a: Financial Institution Depth and Reserve Accumulation

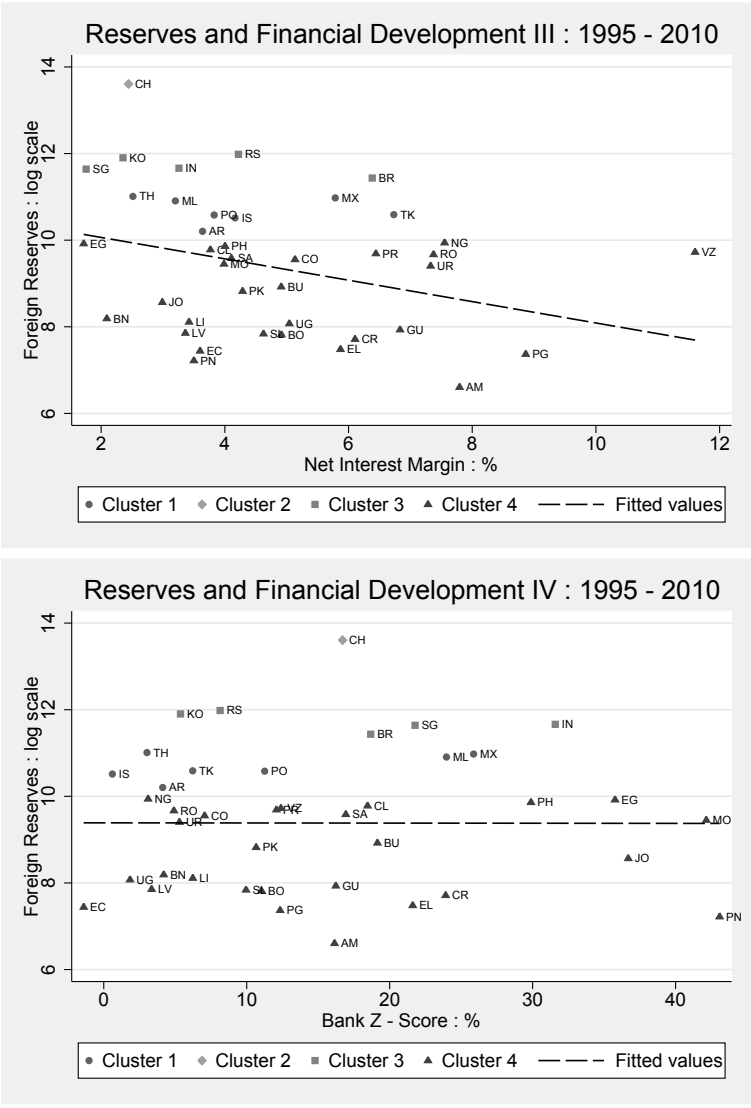


Figure 2.7b: Financial Institution Efficiency, Stability and Reserve Accumulation

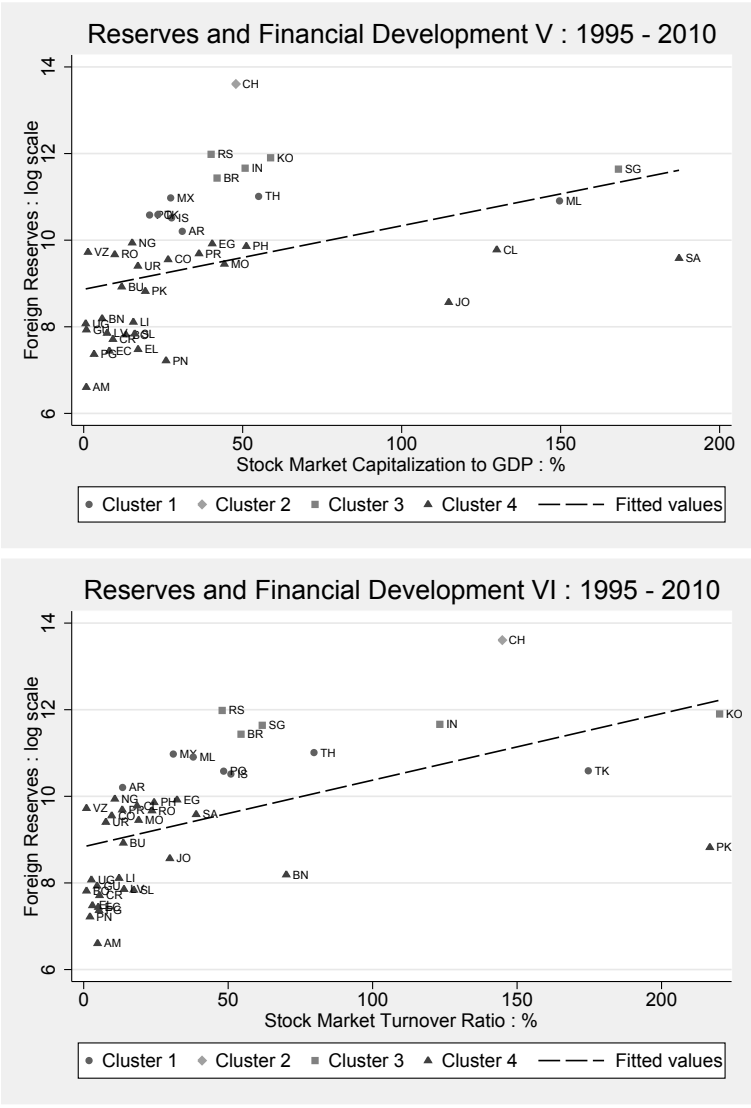


Figure 2.7c: Financial Market Depth, Efficiency and Reserve Accumulation